

LOWER AND EARLY MIDDLE CAMBRIAN TRILOBITES FROM THE PIOCHE SHALE, EAST-CENTRAL NEVADA, U.S.A.

by W. H. FRITZ

ABSTRACT. Trilobites belonging to the Upper *Olenellus* Faunizone (Lower Cambrian) and to the late *Albertella* and *Glossopleura* Faunizones (Middle Cambrian) are described from a single stratigraphic section that spans the Pioche Shale. Trilobites representing the oldest Middle Cambrian, the *Plagiura-Poliella* Faunizone, and the early *Albertella* Faunizone were not found. The interval in which the latter trilobites might be expected contains 260 ft. of barren strata. Four established, two undetermined, and three new species are described from the Upper *Olenellus* Faunizone. Fourteen established, five undetermined, and seventeen new species are described from the late *Albertella* Faunizone and *Glossopleura* Faunizone. Some of these latter species are placed in two new genera, *Achlysopsis* and *Albertelloides*. Seven undetermined and seven new species are described from the *Glossopleura* Faunizone.

The Pioche Shale is locally 1,280 ft. thick and is exposed in an 8,800-ft. section containing Lower, Middle, and Upper Cambrian strata.

MOST of the trilobites described in this paper are from the *Albertella* Faunizone, and all are from the Pioche Shale of the Campbell Ranch section. The approximate limits of the *Albertella* Faunizone are demonstrated by presenting some trilobites from the older Upper *Olenellus* Faunizone and younger *Glossopleura* Faunizone. A few collections contained brachiopods which are not described.

The use of the term faunizone and the zonation framework employed is essentially consistent with that described by Lochman-Balk and Wilson (1958).

At present there is almost no geological information published on the area in which the collections were made. As collecting involved understanding the stratigraphy and structure, considerable data had to be gathered pertaining to these subjects. These data are being compiled on a geologic map and a facing sheet of written description which will be published in 1968 as Nevada Bureau of Mines Map 35.

Geographical location. The Campbell Ranch section is in White Pine County, Nevada. It is located at approximately 114° 56' W. and 39° 33' N. and is within Township 20N near the mutual boundary of Ranges 62 and 63E. The section is exposed on the east flank of the Northern Egan Range and 20 miles north of the town of Ely. It can be approached by automobile along a graded road that parallels the range to the east and passes through the Campbell Ranch. From the ranch the section lies 2½ miles to the northwest. No permanent road leads to the section, however, and it is necessary to turn west just north of the ranch on to the road leading to the Cuba Mine. In one mile this road takes the observer across valley alluvium and close to the Palaeozoic outcrops of the Egan Range. Parking here and looking half a mile northward, one can see a spur sloping eastward that terminates with pink Prospect Mountain Quartzite against valley alluvium. After walking to the quartzite outcrop, the less resistant Pioche Shale can be easily located as the basal Pioche beds overlie the quartzite and are immediately to the west. By continuing northward along the quartzite-shale contact for one mile, one crosses the toe of three spurs, the latter two being similar to the first. The collecting and measuring site for the Pioche Shale is along the crest of the third spur, and the over- and underlying formations were measured on the crest of the second.

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STRATIGRAPHY

Five formations of Lower to early Upper Cambrian age were measured at the Campbell Ranch section. They have a total thickness exceeding 8,800 ft. and can be correlated with type outcrops near Pioche and Eureka, Nevada. In ascending order the formations are Prospect Mountain Quartzite (2,000 ft. +), Pioche Shale (1,280 ft.), Eldorado Limestone (1,385 ft.), Secret Canyon Shale (1,775 ft.), and Hamburg Formation (2,350 ft.). Because the Pioche Shale contains the trilobites to be described, this formation will be discussed in greater detail. The only other formations discussed are those immediately over- and underlying the Pioche Shale.

Prospect Mountain Quartzite

The oldest formation in the Campbell Ranch section is the Prospect Mountain Quartzite which was first described by Hague (1883) from outcrops near Eureka, Nevada. There the formation is considered to be Lower Cambrian in age (Nolan *et al.* 1956, p. 7). To the southeast, in the Grand Canyon region of Arizona, the Prospect Mountain (Tapeats) Quartzite locally contains Middle Cambrian beds in its uppermost part (Wheeler 1948, p. 1796; McKee 1945, p. 36). To the east, in the Wasatch Range, Utah, the Prospect Mountain (Tintic) Quartzite also may contain younger beds of Middle Cambrian age (Walcott 1908*a*, p. 9). Other Prospect Mountain sections in the northern Wasatch may not be younger than Lower Cambrian (Oriel 1964, p. 341). Regional studies by Wheeler (1948) and McKee (1945) have shown that the formation represents near-shore sands deposited by an eastwardly transgressing sea.

At the site of the Campbell Ranch section, approximately 2,000 ft. of the Prospect Mountain Quartzite is exposed between the valley alluvium and the overlying Pioche Shale. As it is typically found elsewhere, the Prospect Mountain is here barren of fossils and is composed of clean, medium- to coarse-grained, cross-bedded quartzite that parts uniformly at intervals averaging 1 ft. in thickness. At the Campbell Ranch section the Prospect Mountain cannot be younger than late Lower Cambrian since a faunule belonging to the Upper *Olenellus* Faunizone is present in the overlying Pioche Shale.

Pioche Shale

This formation was named by Walcott (1908*a*, pp. 9–12) to describe outcrops near Pioche, Nevada. There the formation consists of micaceous siltstone with some interbedded quartzite and limestone. Identifications by Palmer (1964*a*, pp. 25–27) of fossils collected near the type area clearly indicate the Lower Cambrian Upper *Olenellus* Faunizone, give some suggestion of the early Middle Cambrian *Plagiura-Poliella* Faunizone, and adequate evidence of the Middle Cambrian *Albertella* Faunizone.

West of the present area, near Eureka, Nevada, the Pioche has yielded only Lower Cambrian fossils (Nolan *et al.* 1956, p. 8). To the east, in the House Range, Utah, the Pioche contains Lower Cambrian fossils and is immediately overlain by the Tatow (Busby?) Quartzite containing Middle Cambrian trilobites (Wheeler 1948, text-fig. 5).

In the Grand Canyon region, Arizona, the Pioche (Bright Angel) Shale is Lower and Middle Cambrian in age (McKee 1945, text-fig. 1), and the formation is shown to represent a later phase of an eastward Cambrian transgression that began with the deposition of the Prospect Mountain (Tapeats) Quartzite.

At the site of the Campbell Ranch section the Pioche Shale has a lithology which is generally similar to that found near Pioche, Nevada. Two members (text-fig. 1) are recognized at the Campbell Ranch section, a lower siltstone member (420 ft.) and an upper interbedded limestone and siltstone member (860 ft.).

In the lower member the basal 150 ft. consist of brown micaceous siltstone that is exposed at nearby outcrops and weathers to brown dirt on the section. Half a dozen resistant quartzite interbeds averaging $2\frac{1}{2}$ in. in thickness are present within the siltstone unit. The lithology of the quartzite resembles that of the Prospect Mountain Quartzite below.

In the interval 150–160 ft. above the base is a thick-bedded, medium-grey weathering limestone unit (shown as thin-bedded in text-fig. 1 because of scale). The limestone surface is mottled by irregular lenses of siltstone that average 1 in. in thickness. Both a lighter colour and a slightly higher relief distinguish the siltstone from the enclosing limestone. Fossils are common in the uppermost foot of the limestone unit (collection locality 2). Typical fossils in this interval are olenellid fragments, *Onchocephalus papulus*, and *Bommia copia*.

Strata in the interval 160–420 ft. above the base of the lower member weather to brown dirt and contain a few quartzite interbeds. These strata differ from those of the lower siltstone unit in that they include at least three thin to medium interbeds of limestone. Olenellid fragments and *Bommia copia* are common in the first interbed 15 ft. above the base and in the second interbed known from float and located at a slightly higher horizon. The third limestone interbed 150 ft. above the base is barren.

The upper member, consisting partly of shale and possibly some siltstone that weathers to brown dirt, constitutes between a half and two-thirds of the member's thickness. Throughout most of the member are medium to thin interbeds of medium- to dark-grey weathering limestone. Fresh surfaces of the limestone are finely crystalline and nearly black.

At the base of this member is a 2-ft. bed of limestone containing a considerable amount of quartz silt. Abundant specimens of *Girvanella* sp. are conspicuous here and in beds 80 ft. higher in the section. Approximately 65 ft. above the base are beds containing *Albertella judithi* in abundance, and in the lower portion of the member, a few distinctive light-grey bioclastic limestone beds are present. The uppermost 130 ft. is the least resistant portion of the member as it contains almost no limestone. A sharp upper contact of the Pioche Shale is present at the top of this unit and immediately below thick-bedded, very light-grey limestone beds of the Eldorado Formation.

The age of the Pioche Shale at the site of the Campbell Ranch section will be discussed in more detail later in this paper. It will suffice here to state that the oldest two units in the lower member are late Lower Cambrian. It is debatable whether the third, barren unit should be assigned in part or all to the Lower or to the Middle Cambrian. The upper member is probably entirely Middle Cambrian with only the lower 65 ft. being in question. Most of this member can definitely be assigned to the Middle Cambrian *Albertella* and *Glossopleura* Faunizones.

Eldorado Limestone

Walcott (1908b) gave this name to a thick succession of limestone and dolomite between the Pioche Shale and Secret Canyon Shale, near Eureka, Nevada. This original broad usage is followed here, and the Geddes Limestone is not differentiated from the Eldorado, as was later proposed by Wheeler and Lemmon (1939, pp. 20–22).

The Eldorado at the Campbell Ranch section is 1,385 ft. thick, and it contains four members that are briefly described in ascending order as follows: white to very light grey, dense limestone, 260 ft.; dark blue-grey limestone with abundant rod-like structures that are approximately 2 mm. in diameter, 160 ft.; light-grey to cream-coloured dolomite, 200 ft.; and medium-grey limestone, 765 ft. The local age of the Eldorado is Middle Cambrian since *Glossopleura* is present below the formation and a faunule belonging to the *Batthyuriscus-Elrathina* Faunizone was collected a short distance above the top.

Localities and repository. All the trilobites described in this paper are from the Pioche Shale. The approximate stratigraphic position of each locality is shown on text-fig. 1. In order to be more precise, the stratigraphic position above the base of the Pioche is given here for each locality as follows: Loc. 2, 162 ft.; loc. 3, 177 ft.; loc. 1085, ± 223 ft.; loc. 8, 485 ft.; loc. 9, 495 ft.; loc. 10, 510 ft.; loc. 71, 536 ft.; loc. 72, 570 ft.; loc. 11, 623 ft.; loc. 12, 668 ft.; loc. 14, 711 ft.; loc. 15, 742 ft.; loc. 16, 779 ft.; loc. 17, ± 823 ft.; loc. 18, 838 ft.; loc. 74, 1,125 ft. Localities 1085 and 17 are pieces of float thought to have been collected near their sources, but their positions must be questioned. All the trilobites collected are in a limestone matrix.

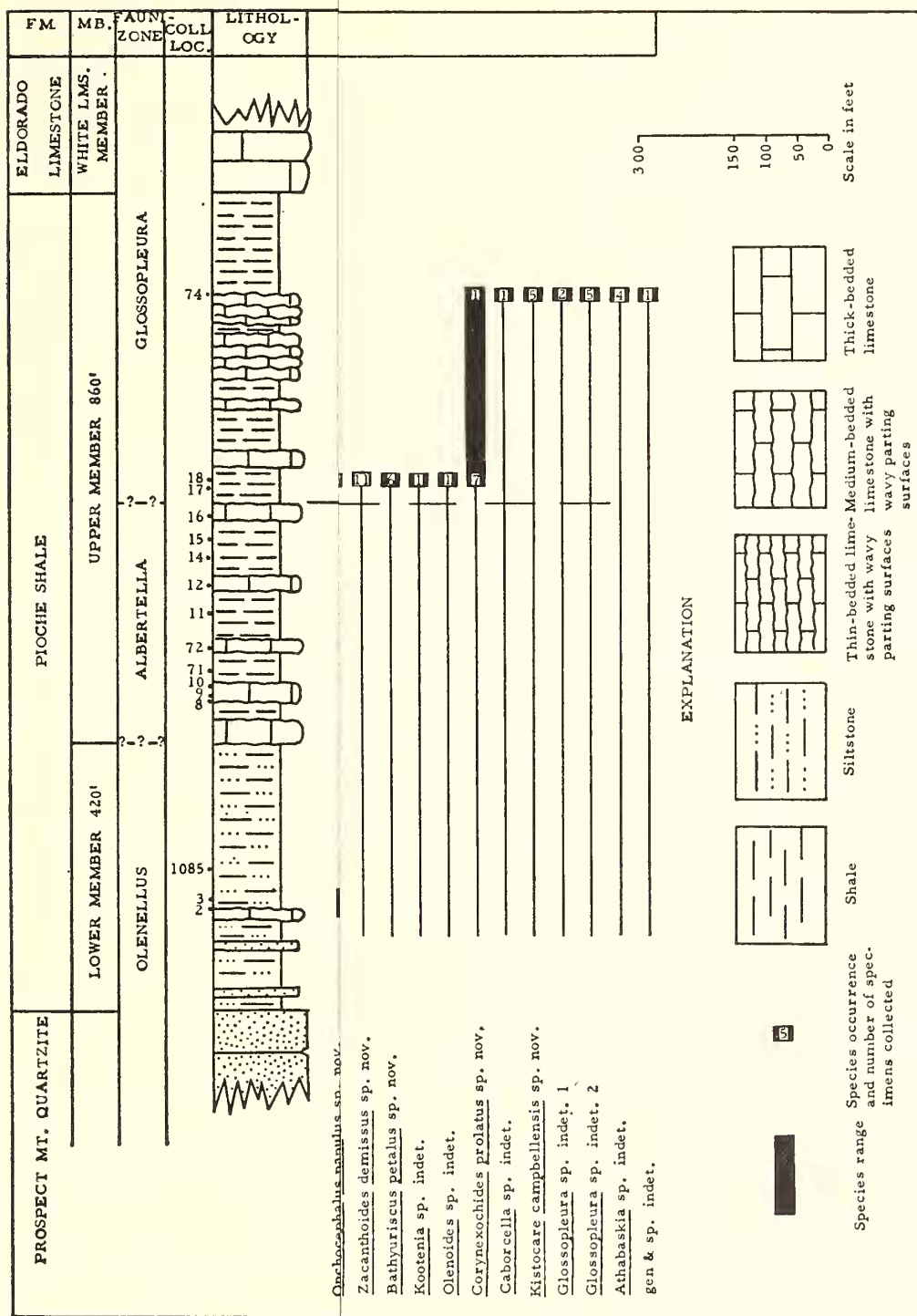
The trilobites are stored at the U.S. National Museum, Washington, D.C. Museum numbers are given in the plate explanations.

BIOSTRATIGRAPHY

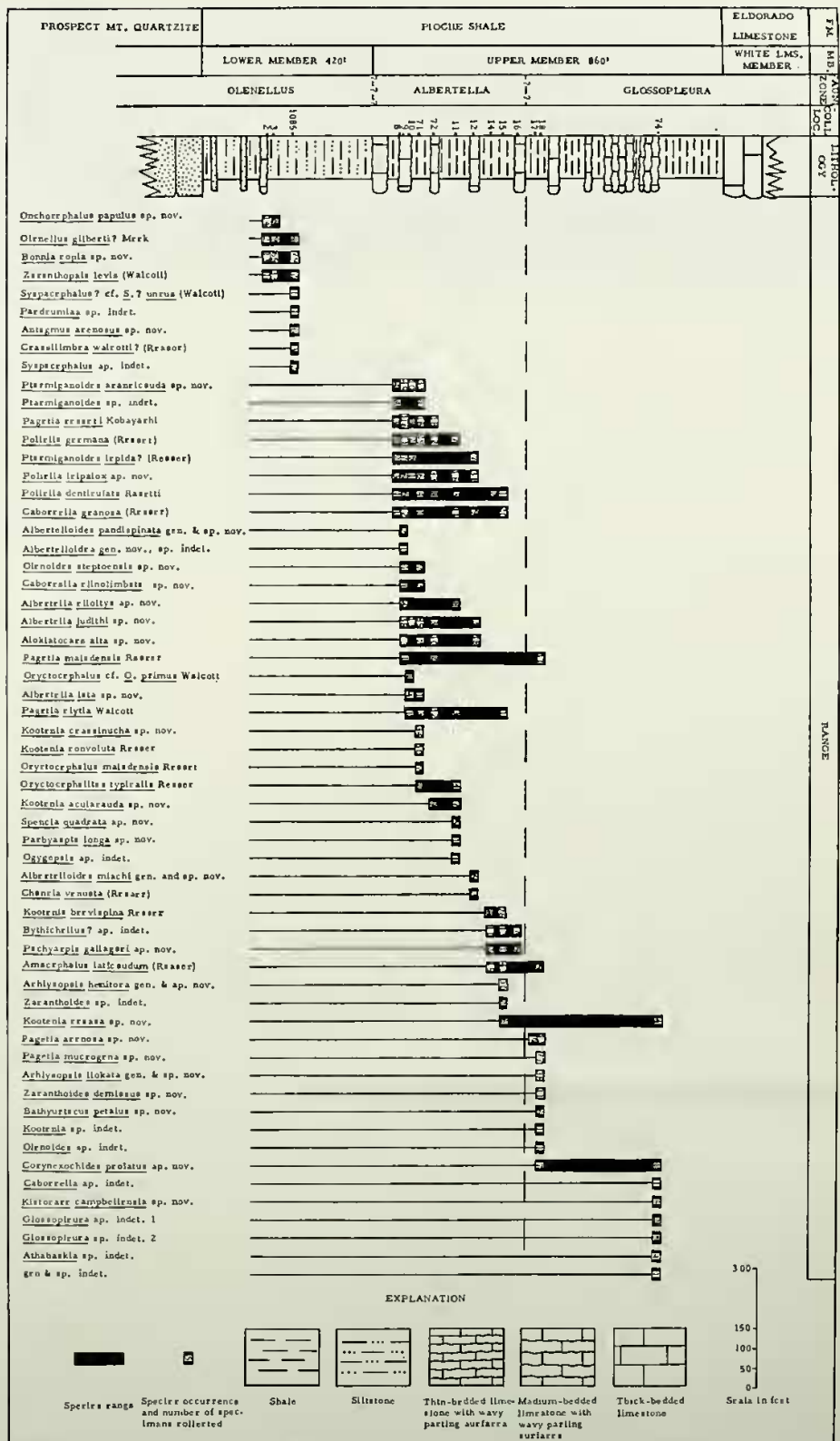
Trilobites from the three localities in the lower member of the Pioche Shale belong to the Upper *Olenellus* Faunizone. *Olenellus gilberti*?, *Bonnia copia*, and *Zacanthopsis levis* are common to all three collections. *Onchocephalus papulus* was found only at the lowest two localities and *Antagmus arenosus*, *Crassifunbra walcotti*?, *Paedeunnias* sp., *Syspacephalus*? cf. *S.?* *uncus*, and *Syspacephalus* sp. indet. were found only at the upper locality. All three collections bear a close resemblance to the *Bonnia fieldensis* faunule from the top of the St. Piran Sandstone of British Columbia (Rasetti 1951, p. 82). Essentially the same faunule has been reported from the Combined Metals Member of the Pioche Shale near Pioche, Nevada by Palmer (1964a, p. 26). A faunule from the Buelna Limestone in Sonora, Mexico (Lochman 1952, p. 71) bears a likeness to the faunule in the three Campbell Ranch collections, but the closest resemblance is to the two former faunules.

The upper member of the Pioche Shale contains trilobites belonging to two faunizones. The oldest, the *Albertella* Faunizone, is represented by collections 8–12, 14–16, 71, and 72. Nineteen genera and twelve species from these localities are common to the '*Ptarmigania* fauna' described by Resser (1939a) from northwestern Utah. The localities containing the '*Ptarmigania* fauna' were later mapped by Williams and Maxey (1941) who found the fossils to be in the Langston Limestone and to be associated with *Albertella*. Their work demonstrated the validity of the *Albertella* Faunizone and its position immediately below the *Glossopleura* Faunizone.

In reviewing the *Albertella* collections from the Campbell Ranch section, it is difficult to believe that they represent the entire *Albertella* Faunizone. Only the lower collections



TEXT-FIG. 1. Chart showing the local range of trilobite species in the Pioche Shale, Campbell Ranch Section, East-Central Nevada, U.S.A.



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(see text-fig. 1) contain the more characteristic trilobites of the faunizone in abundance, such as three species of *Poliella*, two of *Albertella*, and three of *Caborcella*. Thus the Campbell Ranch collections may represent a time interval past the peak of the zone. The 262-ft. interval between the lowest *Albertella* collection and the uppermost Upper *Olenellus* collection is barren and, therefore, the possibility that the *Albertella* Faunizone may extend downward cannot be tested locally.

The close correlation between the *Albertella* collections from the Campbell Ranch section and the 'Ptarmigania fauna' of Utah does not help to position the former collections within the *Albertella* Faunizone. Like the Campbell Ranch collections, the 'Ptarmigania fauna' is underlain by barren beds, and is immediately overlain by the *Glossopleura* Faunizone. Lochman (1952, p. 75) previously concluded that the 'Ptarmigania fauna' represents only the later portion of the *Albertella* Faunizone.

Near the top of the *Albertella* Faunizone there is a definite pattern of transition toward the overlying *Glossopleura* Faunizone (see text-fig. 1). Unfortunately, no fossils were found in the 287-ft. interval between locality 18 and the only *Glossopleura*-bearing locality, locality 74. This lack of data detracts from the reliability of a local horizon chosen to represent the mutual boundary of the *Albertella* and *Glossopleura* Faunizones. Enough data are present, however, to tentatively locate this boundary pending the finding of more fossil localities or more fossiliferous sections elsewhere. The tentative boundary selected is between localities 16 and 17 where a significant faunal change occurs. Near or just below this boundary the teilzone terminates for the following characteristic trilobites in the Campbell Ranch section: *Bythlicheilus?* sp., *Caborcella granosa*, *Kootenia brevispina*, *Pachyaspis gallagari*, *Pagetia clytia*, and *Poliella denticulata*. Common to the *Albertella* and *Glossopleura* Faunizones are *Amecephalus laticaudum*, *Kootenia crassa*, and *Pagetia maladensis*. The genus *Caborcella* is represented in both faunizones, but by different species.

The *Glossopleura* Faunizone is unquestionably represented at locality 74. Two species of *Glossopleura* and one of *Kistocare* are considered reliable faunizone indicators. Less weight is given to *Athabaskia* as its range may possibly extend downward into the *Albertella* Faunizone in British Columbia (Rasetti 1951, p. 96). The age of *Corynexochides* has thus far been uncertain, although Rasetti (1963, p. 576) does suggest that two species found in boulders near Metis, Quebec, may belong to the *Glossopleura* Faunizone. The species from the Campbell Ranch section is definitely from the *Glossopleura* Faunizone and is the first to be reported from the North American Cordillera.

Below locality 74 and above the tentative base of the *Glossopleura* Faunizone are localities 17 and 18. As they are closely spaced, and as the single species present at 17 is also present at 18, the two localities can be discussed together. Here there is an early occurrence of *Bathyriscus*. A second early occurrence of the genus was reported by Rasetti (1951, p. 96) from British Columbia where it may extend downward into the *Albertella* Faunizone. A third is known from one small pygidium, *Bathyriscus politus*, which Resser (1939a, p. 30) described from northwestern Utah. As this pygidium is associated with the 'Ptarmigania fauna', it can be assumed to belong to the *Albertella* Faunizone.

Except for *Pagetia maladensis*, the more abundant species just above the tentative base of the *Glossopleura* Faunizone (loc. 17-18) are new. These are *Achlysopsis liokata*, *Pagetia arenosa*, *Pagetia mucrogena*, and *Zacanthoides demissus*. As Resser (1939a, p. 25)

has described *P. maladensis* from the '*Ptarmigania* fauna' of northwestern Utah, the species can be said to range down into the upper portion of the *Albertella* Faunizone in that region, as it does here.

Between the localities bearing fossils from the Upper *Olenellus* and late *Albertella* Faunizones is a barren interval in which no representatives of the intermediate *Plagiura-Poliella* and early *Albertella* Faunizones were found. The stratigraphic interval within which the apparent break occurs is the barren 262 ft. between localities 1085 and 8. Four hypotheses that might explain the missing faunules are as follows: (1) fossils are only locally missing because they have been faulted from the section; (2) strata in the barren interval were deposited during a time when the *Plagiura-Poliella* and early *Albertella* faunas were locally evolving, but no fossil record was preserved; (3) an unconformity is present within the interval in question; (4) representatives of the late Upper *Olenellus* Faunizone (Lower Cambrian) in the Campbell Ranch section lived here at a time when a laterally equivalent *Plagiura-Poliella* fauna ('Middle Cambrian') and possibly part of the *Albertella* fauna lived in what is now British Columbia, the type area for the *Plagiura-Poliella* Faunizone.

The first hypothesis seems unlikely, as a considerable area was mapped surrounding the Campbell Ranch section to ensure that a fault would not be overlooked.

The second hypothesis can best be approached by considering the fossils immediately under and overlying the barren interval in question. The three underlying localities contain a typical late Lower Cambrian faunule, but there are no 'transition' elements to suggest that Middle Cambrian strata are just above the highest of the three localities. The first locality above the barren interval contains fossils that can be placed in the later part of the *Albertella* Faunizone or, in other words, well into the Middle Cambrian. As the thickness of the barren interval is less than that occupied by the later part of the *Albertella* Faunizone, either slow deposition or rapid evolution must have taken place if the second hypothesis is correct.

The third hypothesis is similar to one considered by Rasetti (1951, p. 87) who concluded that a regional unconformity may exist in the North American Cordillera between strata of Lower and Middle Cambrian age. He has mentioned that published data from various areas in the Cordillera indicate a sharp faunal break at this horizon, and he has presented evidence that a physical and faunal break exists at this boundary in British Columbia. Regional studies by Wheeler (1948) and McKee (1945) give no clue of such an unconformity and, indeed, contain data that could be used to counter Rasetti's conclusion. Should regional investigations be made to pursue the unconformity question in the future, early attention will undoubtedly focus on the Busby Quartzite. This or similar clastic units are present at the top or overlying the Pioche Shale in various sections in eastern Nevada and western Utah. At the Campbell Ranch section no physical evidence of an unconformity was noted nor is the Busby Quartzite present.

The fourth hypothesis entertains the possibility that the top of the Lower Cambrian, locally a horizon immediately overlying the youngest olenellids, may not be a 'time' plane even in the geologic sense. It may transgress time as do boundaries of an ecozone as visualized by Vella (1964). Locally an ecozone boundary is a record of an abrupt faunal change that occurred due to a sudden change in environment. At the Lower-Middle Cambrian boundary in what is now the Great Basin such a displacement of faunas may have occurred, as here the Lower Cambrian consists predominantly of sandstone and siltstone and the Middle Cambrian of limestone and shale.

Furthermore, the bulk of the immediate ancestors to the Middle Cambrian faunas have not been found here. We can assume that these ancestors did intermix with olenellids in a more seaward environment during late Lower Cambrian time because in rare localities, such as near Goldfield, Nevada (Palmer 1964b), a record of this intermixing has been found. If, at the same time and slightly further seaward, Middle Cambrian stocks completely displaced the olenellids, we would not recognize this fauna as being Lower Cambrian. The 'Middle Cambrian' *Plagiura-Poliella* Faunizone in British Columbia might represent such a seaward displacement. To pursue this hypothesis to what is admittedly

an extreme position, we might suppose the faunal displacement proposed above existed and remained effective for a considerable length of time. Still pressing towards the extreme, we might assign only a short amount of time to the deposition of the barren strata in question. Having done this, we could then equate a post-olenellid *Plagiura-Poliella* and lower *Albertella* Faunizone in British Columbia to a latest Upper *Olenellus* Faunizone in the Campbell Ranch section.

None of the last three hypotheses can be favoured without overemphasizing the meagre data available. However, these three hypotheses do serve to illustrate the gaps in our understanding of late Lower and early Middle Cambrian faunas, and they may suggest an approach preferable to describing random collections of that age. To the writer, they suggest a need to emphasize the study of stratigraphically allocated collections that demonstrate the crossing of at least one zonal boundary. The first hypothesis suggests that collecting be done only after the local geology is understood by the collector.

SYSTEMATIC PALAEONTOLOGY

Class TRILOBITA Walch 1771

Order AGNOSTIDA Kobayashi 1935

Family PAGETIIDAE Kobayashi 1935

Genus PAGETIA Walcott 1916

Pagetia arenosa sp. nov.¹

Plate 43, figs. 10, 11

Material. Seven cranidia 0.8–2.1 mm. long and fifteen pygidia 0.4–2.3 mm. long.

Description. Cranidium wider than long by ratios ranging from approximately 2:2 to 3:4. Glabella small, tapered forward, front portion even with or slightly below level of fixigenae and terminating well back of border furrow. Three faint sets of glabellar furrows, anterior two sets transversely directed, anterior set joining, posterior set inclined toward rear. Postglabellar spine tapers uniformly back to a node, remaining spine is narrow, total length at least equalling and probably exceeding that of glabella. Fixigenae convex in both directions. Eye ridges thin but distinct. Palpebral lobes thin, broadly curved; palpebral furrow narrow but well impressed. Anterior border wider than border furrow; radial marking well impressed but irregular in spacing and depth.

Pygidium has length–width ratios that are approximately the same as those of cranidium. Axis narrower than pleural field, composed of four distinct rings bearing nodes, one poorly defined ring, and a terminal piece with spine. Pleural field exhibits weak pleural furrows. Some pygidia show faint interpleural furrows paralleled by a row of very small granules. Border uniformly narrow and horizontal. Pygidial surface rough but not distinctly granular, cranidium obviously granular, especially palpebral areas.

Remarks. *Pagetia arenosa* most resembles *Pagetia clytia* Walcott 1916, but differs in having lower fixigenae, a locally swollen palpebral area, well-defined eye ridges and palpebral lobes, a narrower pygidial axis, and a rough to granular test.

Occurrence. *Glossopleura* (?) Faunizone, upper member, localities 17 and 18.

¹ This species was preoccupied by *Pagetia rugosa* Rasetti 1966 (p. 509) after submission of this paper. (See RASETTI, F., 1966. Revision of the North American species of the Cambrian trilobite genus *Pagetia*. *J. Paleont.* **40**, 502–11, pl. 59, 60.)

Pagetia clytia Walcott

Plate 38, figs. 10, 11

- 1916b *Pagetia clytia* Walcott, p. 408, pl. 67, figs. 2, 2 a-e.
 1920 *Pagetia clytia* Walcott; Raymond, p. 145, fig. 37.
 ? 1935 *Pagetia clytia* Walcott; Mason, pp. 114, 115.
 non 1939a *Pagetia clytia* Walcott; Resser, pp. 25, 26, pl. 2, figs. 5-8.
 1939b *Pagetia clytia* Walcott; Resser, p. 8, pl. 2, figs. 30-32.
 1943 *Pagetia (Mesopagetia) clytia* Walcott; Kobayashi, p. 40.
 1944 *Pagetia (Mesopagetia) clytia* Walcott; Kobayashi, p. 64, pl. 1, fig. 14.
 1944 *Pagetia clytia* Walcott; Shimer and Shrock, p. 615, pl. 252, figs. 13-15.

Material. Twenty cranidia 1.3-2.5 mm. long and twenty pygidia 1.0-2.0 mm. long.

Description. Cranidium as wide or slightly wider than long. Axial furrow deep and wide, abruptly changes to moderate width opposite and anterior to eye ridges. Glabella uniform in width except for anterior third which tapers forward; glabella lightly furrowed, anterior set transverse and joining, median set directed forward, posterior set directed back, latter two sets closely spaced and visible only as small indentations on most specimens. Fixigena plump, top surface broadly curved (exsag.) and dips uniformly inward; palpebral area well rounded near outer margin and almost vertical near facial suture; postero-lateral region of fixigena has a steep, almost facet-like surface on some specimens. Anterior border defined by wide furrow, radial markings deep, alternate markings deeper and longer. Eye ridges located just forward of anterior pair of glabellar furrows, visible only near dorsal furrow. Palpebral lobes very weakly outlined by a narrow furrow. Postglabellar spine thick.

Pygidial length approximately three-quarters width. Axis narrow, composed of a rather long (sag.) articulating half ring, five axial rings, and terminal piece with spine; anterior axial ring short (sag.), remaining rings of uniform size, last ring poorly defined from terminal piece. Up to three pleural furrows barely visible on pleural field. Border uniformly narrow except for being very narrow at back. Outer surface of test nearly smooth.

Remarks. *Pagetia clytia* resembles *Pagetia bootes* Walcott 1916, but has a stronger postglabellar spine, weaker eye ridges, and a glabella that extends closer to the border furrow.

Occurrence. *Albertella* Faunizone, upper member, localities 10, 71, 72, 11, and 15.

Pagetia maladensis Resser

Plate 43, figs. 14-16

- 1939a *Pagetia maladensis* Resser, p. 25, pl. 2, figs. 4 (cranidium only) and 5 (cranidium in upper right only).
 ? 1943 *Pagetia (Mesopagetia) maladensis* Resser; Kobayashi, p. 40.
 1944 *Pagetia (Mesopagetia) maladensis* Resser; Kobayashi, pp. 64-66, pl. 2, fig. 4a (non fig. 4b).

Material. Four cranidia 1.2-1.5 mm. long and ten pygidia 0.9-1.7 mm. long.

Description. Cranidium wider than long. Glabella narrow, front half level with fixigenae, back half rises above locally back-sloping fixigenae, sides straight and slightly converging, front abruptly pointed. One set of glabellar furrows visible as slight indentations

on anterior sides of glabella. Palpebral area convex in both directions; eye ridges broad and low. Palpebral lobes defined by very shallow furrow. Anterior border furrow shallow, deepening medially where it connects back to axial furrow. Border of fairly uniform width, radial markings narrow, some markings inclined considerably off a truly radial course. Postglabellar spine long, thin, and bearing a node.

Pygidial length-width ratio approximately 3:4. Axis narrow, sides parallel, posterior relief high above pleural field, extending slightly beyond posterior margin of border; axis composed of two node-bearing rings followed by one or two faintly defined rings and long terminal piece. Spine present on postero-dorsal surface of terminal piece is uptilted and uniformly thin. Border furrow shallow and of uniform depth. Border downsloping, convex, widening at postero-lateral positions. Outer surface of test nearly smooth.

Remarks. In describing this species Resser assigned the wrong pygidia to his holotype cranidium. His assigned pygidia are on average larger than those of *P. maladensis*, are punctate, and belong to unnamed cranidia which Resser (1939a, p. 65, pl. 2, fig. 5) misidentified as *Pagetia clytia* Walcott 1916. Unmentioned pygidia of *P. maladensis* are visible in one of Resser's figures (pl. 2, fig. 4), and others are present in material from the same collection. *Pagetia maladensis*, as here defined, closely resembles *Pagetia ferox* Lermontova 1940. Poor figures of *P. ferox* plus the lack of access to comparative material preclude a detailed comparison of the two species.

Occurrence. *Albertella* and *Glossopleura* (?) Faunizone, upper member, localities 9, 18, and 72.

Pagetia mucrogena sp. nov.

Plate 43, figs. 12, 13

Material. Forty-seven cranidia 0.9–1.8 mm. long and thirty pygidia 0.7–1.5 mm. long.

Description. Cranidium with length-width ratio ranging between 4:5 and 7:8. Glabella tapers gradually forward, anterior one-fifth tapers rapidly to a point touching or nearly reaching border furrow. Three faint sets of evenly spaced glabellar furrows, all sets transversely directed, forward set joining, second set weakest, posterior set with branch directed back. Axial furrow of uniform width and depth. Fixigenae slope moderately inward, palpebral areas distally extended into blunt points. Palpebral lobes uniformly narrow, outlined on points by a very faint furrow, neither furrows nor lobes visible on most specimens. Eye ridges weak and visible on only a few specimens. Anterior border and border furrows uniform in width and sharply defined. Postglabellar spine thick at base, uniformly tapered; spine on numerous specimens has a thin medial ridge on dorsal surface that extends across union of spine and glabella.

Pygidium with length-width ratios ranging from 2:3 (small pygidia) to 7:8 (large pygidia). Axis composed of five distinct rings and a terminal piece, each bearing a spine or large node; axis narrower than pleural field on small pygidia, equal in width on larger. Pleural furrows of medium depth near axis, shallow near border; interpleural furrows faint on smaller specimens, not visible on others. Border uniformly narrow, downsloping, not as wide as border furrow. Ornamentation on cranidium consists of radial markings only; pygidium has single rows of small granules located between and parallel

to pleural furrows. Granules visible on most small pygidia, visible on some medium to large pygidia.

Remarks. *Pagetia fossula* Resser 1938a resembles this species in many respects, but differs by having (1) palpebral areas with less lateral distension, (2) palpebral lobes that are clearly defined, (3) a narrower pygidial axis with less longitudinal curvature, (4) only four well-defined axial rings, and (5) shallower furrows on the pleural field.

Occurrence. *Glossopleura* (?) Faunizone, upper member, locality 18.

Pagetia resseri Kobayashi

Plate 38, figs. 8, 9

1939a *Pagetia clytia* Walcott; Resser, p. 25, pl. 2, figs. 6–8 (*non* fig. 5).

1943 *Pagetia* (*Eopagetia*) *resseri* Kobayashi, p. 40.

1944 *Pagetia* (*Eopagetia*) *resseri* Kobayashi; Kobayashi, pp. 64–66, pl. 2, figs. 2a, b.

Material. Fifty-four cranidia 0.9–2.0 mm. long and 104 pygidia 0.8–1.8 mm. long.

Description. Cranidium as wide as long or slightly wider. Axial furrow of medium depth and width. Glabella rises above fixigenae along entire length, sides parallel at back, forward two-thirds converges to a point which touches or almost reaches border furrow. Three shallow sets of glabellar furrows, all sets directed transversely, posterior two sets closely spaced, rear set has posteriorly directed branch. Fixigenae low, broadly curved (exsag.), and nearly horizontal in transverse profile. Palpebral lobes uniformly narrow, parallel to axial furrow, length approximately one-third cranidial length. Palpebral furrow narrow, well impressed, paralleled at inner edge by a sharp ridge that is more pronounced on smaller cranidia. Eye ridges faint or not visible. Anterior border narrower than border furrow, border–border furrow contact gradational, radial markings short. Postglabellar spine initially strong, rapidly tapering, thin prolongation continues back for a distance equalling length of strong portion plus length of glabella. Surface of well-preserved cranidia exhibit very sparse granules, most fixigenae exhibit a pair of granules opposite posterior margin of glabella.

Pygidial length–width ratios range from 2:3 to slightly greater than 4:5. Axis considerably wider than pleural field, consisting of five rings with prominent nodes or spines and terminal piece bearing a node or spine. Pleural field marked by moderately impressed pleural furrows, weak interpleural furrows, and two closely spaced rows of granules on either side of interpleural furrows. Border not as wide as border furrow, tilted outward, and marked with granules.

Remarks. Resser (1939a) described two pygidia and a cranidium of this species with two cranidia of an unnamed species. He wrongly placed all under the name *Pagetia clytia* Walcott 1916. *Pagetia resseri*, as here interpreted, differs from other species of *Pagetia* at present known from North America in having a pygidium with a very broad axis, a well-furrowed pleural field, and abundant ornamentation.

Occurrence. *Albertella* Faunizone, upper member, localities 8–10, 71, and 72.

Order REDLICHIIIDA Richter 1933
Family OLENELLIDAE Vodges 1893
Genus OLENELLUS Billings 1861

Type species. *Olenus thompsoni* Hall 1859.

Olenellus gilberti? Meek

Plate 36, figs. 26–28

- 1874 *Olenellus gilberti* Meek in White, p. 7.
1910 *Olenellus gilberti* Meek; Walcott, pp. 324–30, pl. 36, figs. 1–17, pl. 43, figs. 5, 6 (synonymy to date).
1916b *Mesonacis gilberti* (Meek); Walcott, pp. 406–7, pl. 45, fig. 3.
1944 *Olenellus gilberti* Meek; Shimer and Shrock, p. 613, pl. 253, figs. 2, 3.
1952 *Olenellus gilberti* Meek; Best, pp. 17, 18, pl. 1, figs. 13–17.
1962 *Olenellus gilberti* Meek; Norford, p. 6, pl. 1, figs. 8, 9.

Material. Fifteen incomplete glabellae 1.3–24.0 mm. long and various other cephalic parts.

Description. Glabella moderately raised, parallel-sided, front rounded and nearly reaching border. Three sets of glabellar furrows, all straight, all inclined toward rear, each pair inclined less strongly than pair in front, median pair shortest, anterior and median pairs do not reach glabellar margin. Occipital ring approximately the same size as adjacent glabellar lobe and bearing a small spine. Ocular lobes abruptly elevated at margins, long and narrow, terminating well posterior to occipital furrow.

Remarks. Most of the material resembles like parts of *Olenellus gilberti* Meek, but the collection is too incomplete for definite identification.

Occurrence. Upper *Olenellus* Faunizone, lower member, localities 2, 3, and 1085.

Genus PAEDEUMIAS Walcott 1910

Type species. *Paedeumias transitans* Walcott 1910.

Paedeumias sp. indet.

Plate 36, fig. 25

Material. One incomplete internal mould of a cephalon approximately 25 mm. long.

Description. Cephalon broadly convex, length–width ratio approximately 2:3. Glabella slightly concave along sides, widest at posterior end, anterior lobe pointed and terminating well posterior to border. Ocular lobes long and narrow, uniformly curved along outer margin, directed strongly back, terminating close to posterior border and to postero-lateral corner of occipital ring. Border uniformly narrow.

Remarks. A narrow border and a considerable distance between the border and the anterior lobe of the glabella serve to differentiate this specimen from other olenellids in

the Campbell Ranch section. These two features are considered diagnostic of the genus *Paedeumias*.

Occurrence. Upper *Olenellus* Faunizone, lower member, locality 1085.

Order CORYNEXOCHIDA Kobayashi 1935

Family DORYPYGIDAE Kobayashi 1935

Genus BONNIA Walcott 1916

Type species. *Bathyrus parvulus* Billings 1861.

Bonnia copia sp. nov.

Plate 36, figs. 17–24

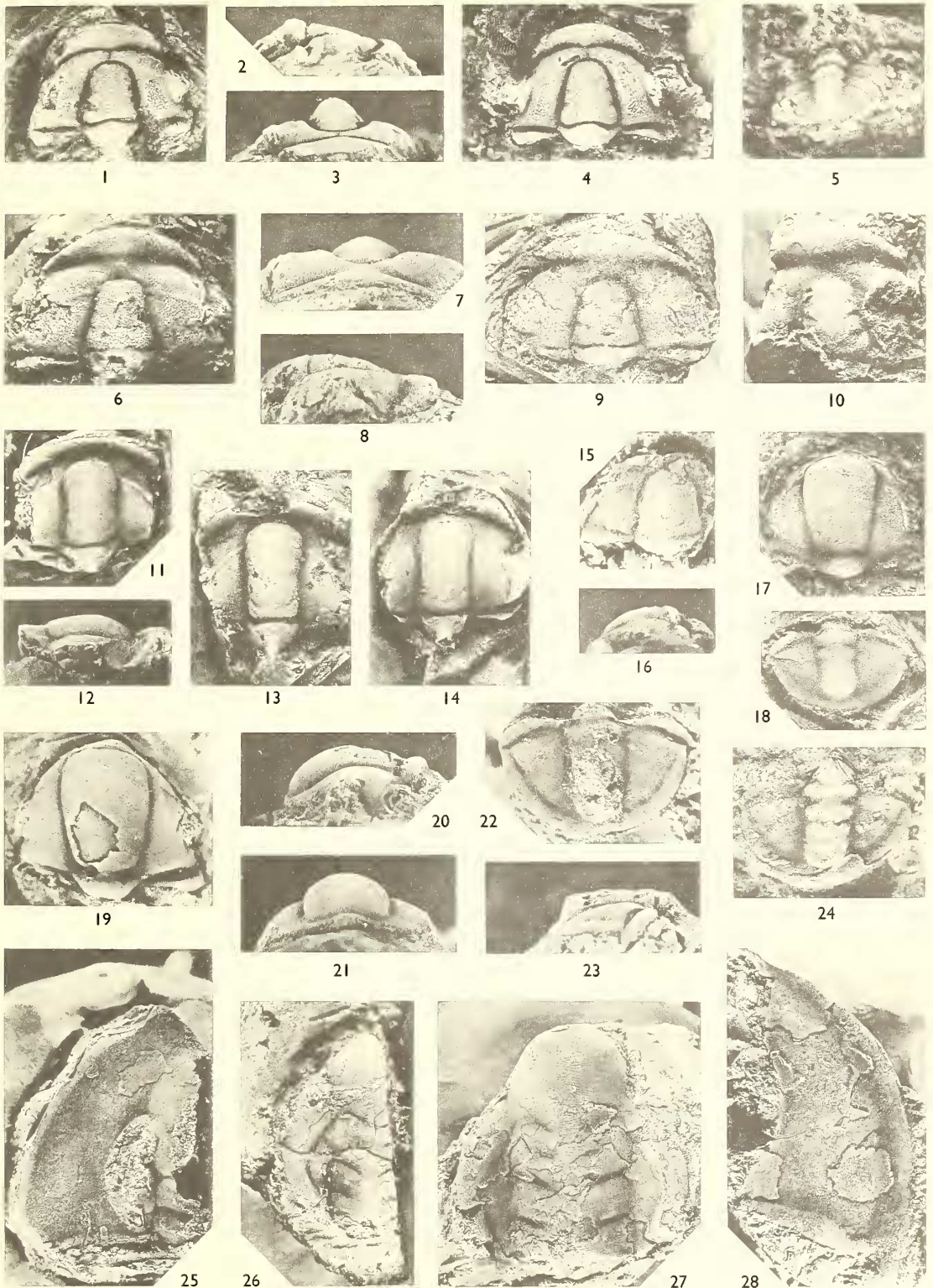
Material. Eighty-nine cranidia 2.0–11.0 mm. long and sixty-eight pygidia 3.2–13.0 mm. long.

Description. Cranidium moderately convex, slightly wider across palpebral lobes than long. Glabella expands forward, strongly so on small cranidia, moderately so on large; all sizes broadly curved across front. Glabellar furrows weak, posterior set short and wide, remaining three sets faintly visible on internal moulds only, all sets probably branch. Axial furrow broadly convex outwards to nearly straight, of medium depth and width, considerably deeper and wider on internal moulds. Fixigenae downsloping, broadly curved in both directions. Palpebral lobes and furrows narrow, furrows much stronger on peeled specimens. Eye ridges visible only on internal moulds; they are low and located just posterior to border furrow. Anterior border narrow and slightly up-warped in front view. Posterior border furrow wide and expanding distally. Occipital ring bears a node on some specimens, a very small spine on others.

EXPLANATION OF PLATE 36

Upper *Olenellus* Faunizone.

- Figs. 1–5. *Onchocephalus papulus* sp. nov. (p. 224). 1–3, Holotype cranidium, plan, side, and front view, $\times 6.2$, USNM 153529. 4, Paratype cranidium, $\times 7.6$, USNM 153530. 5, Tentatively assigned pygidium with one attached thoracic segment, $\times 27.0$, USNM 153531. All specimens from loc. 2.
- Figs. 6–10. *Antagmus arenosus* sp. nov. (p. 220). 6–8, Holotype cranidium, plan, front, and side view, $\times 3.1$, USNM 153532. 9, Paratype cranidium, partially peeled, $\times 3.1$, USNM 153533. 10, Paratype cranidium, mostly peeled, $\times 3.3$, USNM 153534. All specimens from loc. 1085.
- Figs. 11–14. *Zacanthopsis levis* (Walcott) (p. 217). 11, 12, Cranidium, plan and side view, $\times 3.5$, USNM 153535, loc. 3. 13, Cranidium, mostly peeled, $\times 4.7$, USNM 153536, loc. 3. 14, Cranidium, $\times 4.1$, USNM 153537, loc. 1085.
- Figs. 15, 16. *Syspacephalus*? cf. *S. ?uncus* (Walcott) (p. 225). Cranidium, plan and side view, $\times 11.6$, USNM 153538, loc. 1085.
- Figs. 17–24. *Bonnia copia* sp. nov. (p. 194). 17, Paratype cranidium, small, $\times 4.5$, USNM 153539, loc. 3. 18, Paratype pygidium, small, $\times 4.5$, USNM 153540, loc. 3. 19–21, Holotype cranidium, plan, side, and front view, $\times 3.5$, USNM 153541, loc. 2. 22, 23, Paratype pygidium, plan and side view, $\times 4.3$, USNM 153542, loc. 2. 24, Paratype pygidium, mostly peeled, $\times 5.4$, USNM 153543, loc. 3.
- Fig. 25. *Paedeumias* sp. indet. (p. 193). Partial cephalon, mostly peeled, $\times 0.6$, USNM 153544, loc. 1085.
- Figs. 26–28. *Olenellus gilberti*? Meek (p. 193). 26, Partial glabella and ocular lobe, partially peeled, $\times 0.6$, USNM 153545. 27, Glabella and ocular lobes, partially peeled, $\times 0.5$, USNM 153546. 28, Gena, partially peeled, $\times 0.6$, USNM 153547. All specimens from loc. 1085.



Pygidium has length-width ratio of approximately 2:3. Axis consists of one well-defined ring, one poorly defined ring, and terminal piece; internal moulds exhibit four rings and terminal piece. Pleural field lightly marked by pleural furrows; peeled specimens show three strong pleural furrows and their faint continuations across border furrow and border. Border fairly uniform except for slight reduction of width and broadening of curvature posterior to axis. Test nearly smooth, terrace lines present on anterior border and on front of glabella.

Remarks. Cranidia of *Bonnia copia* resemble those of *Bonnia fieldensis* (Walcott) 1916. However, the anterior border is not directed as strongly back along its distal portions on *B. fieldensis*. Pygidia of *B. fieldensis* are lower, relatively longer, and have lateral margins that trend more strongly rearward before curving abruptly into a broadly arcuate rear margin. Thus the pygidial outline of *B. fieldensis* has a more 'squared' appearance than does that of *B. copia*. *Bonnia sonora* Lochman 1952 is similar to the above two species, but is represented by only one small cranidium and seven poorly preserved pygidia and thus is difficult to compare at the specific level.

Occurrence. Upper *Olenellus* Faunizone, lower member, localities 2, 3, and 1085.

Genus KOOTENIA Walcott 1889

Type species. *Bathyriscus (Kootenia) dawsoni* Walcott 1889.

Kootenia acnlaacauda sp. nov.

Plate 41, figs. 1-8

Material. Twelve cranidia 1.8-11.2 mm. long and four pygidia 3.1-6.9 mm. long.

Description. Cranidium convex, length approximately three-quarters width across palpebral lobes. Glabella of medium height, sides parallel, front broadly curved. Glabellar furrows not visible except for three shallow sets on smallest cranidium, all sets fork, anterior two have one branch inclined forward and one inclined back, posterior set has transverse branch and branch inclined back. Palpebral area wide, convex, average slope is outward. Eye ridges broad and low. Palpebral furrows very wide and of moderate depth. Palpebral lobes narrow, centred posterior to glabellar midpoint, set well below level of axial furrow, nearly one-third as long as glabella. Border narrow in front of glabella, broadens considerably and then narrows near ends. Posterior area as wide (tr.) as occipital ring and traversed by a deep, broad furrow. Occipital furrow of medium depth near ends, shallow medially. Occipital ring very short (sag.), bearing a thin, uptilted spine.

Pygidium moderately convex, length-width ratio slightly less than 2:3. Axis nearly cylindrical, tapered slightly toward rear, consisting of three rings and rather long terminal piece. Pleural field of medium convexity, steep near border furrow, marked by three prominent and one weak pleural furrow and three faint interpleural furrows. Border narrow, bearing six sets of short, thin spines, anterior four sets slightly divergent. Surface of cranidium marked by terrace lines on anterior border and on part of occipital

ring; irregular granules of medium size locally fuse on large areas of cranidium and pygidium to give pitted as well as granular appearance.

Remarks. Cranidia and pygidia of *Kootenia germana* Resser 1939a most closely resemble those of this species. Cranidia of *K. germana* have a higher glabella, an anterior border of more uniform breadth, and a much narrower palpebral area. Pygidia have pleural areas that are less convex and a posterior set of spines that are more closely spaced. Three species of *Kootenia* from the Campbell Ranch section have six-spined pygidia as does *K. aculacauda*. Of these, *K. brevispina* and *K. sp. indet.* have short, rapidly tapering pygidial spines that are obviously different from those of *K. aculacauda*. Pygidial spines of *K. crassa* superficially resemble the narrow spines of *K. aculacauda*, but they are longer and somewhat flattened. The area occupied by the spines of *K. crassa* approximately equal the interspaces between, while the interspaces between spines of *K. aculacauda* are proportionately far wider.

Occurrence. *Albertella* Faunizone, upper member, localities 72 and 11.

Kootenia brevispina Resser

Plate 40, figs. 1-6

1939a *Kootenia brevispina* Resser, p. 50, pl. 11, figs. 1-4.

Material. Fifty-seven cranidia 5.0-14.5 mm. long, twenty-seven pygidia 2.6-11.4 mm. long, and five hypostomata.

Description. Cranidium moderately convex, length almost equals width across palpebral lobes. Glabella of medium height, sides parallel, curvature broad to medium in front. Two faint, broad sets of glabellar furrows visible on some specimens. Palpebral area narrow and downsloping. Palpebral furrows of medium depth and width; palpebral lobes centred posterior to glabellar midpoint, length between one-quarter and one-third that of glabella. Ocular ridge low and broad. Anterior border furrow shallow. Posterior area narrower (tr.) than occipital ring, distal margin rounded. Occipital furrow of moderate depth and width. Occipital ring bears a short spine. Hypostoma has elongate medial body with sides converging only slightly toward rear. Maculae shallow and steeply inclined toward rear. Lateral border furrows broad and of medium depth; anterior and posterior border furrows narrow. Anterior margin of hypostoma sharply downwarped near axial line.

Pygidium of medium convexity, length two-thirds width. Axis consists of three rings and a terminal piece. Pleural area marked by three medium pleural furrows and two weak interpleural furrows. Border flat, rather wide, downsloping. Six sets of flat, short, marginal spines, posterior three closely spaced, anterior three more widely spaced, posterior five shaped like teeth on a saw. Surface of cranidium and pygidium covered with fine granules, moderately worn areas appear pitted, strongly worn, smooth.

Remarks. Resser (1939a) erected three additional species from material that resembles *Kootenia brevispina*, but lacks the necessary detail for adequate comparison at specific level. Represented by this poor material are *Kootenia venusta* (cranidium only), *Kootenia*

mendosa, and *Kootenia pectenoides*. Another species, *Kootenia serrata* (Meek) 1873 resembles *K. brevispina*, but has a wider palpebral area and narrower, inwardly directed pygidial spines. *Kootenia brevispina* can be readily distinguished from other species of *Kootenia* in the Campbell Ranch collections by its six sets of broad, short, pygidial spines.

Occurrence. *Albertella* Faunizone, upper member, localities 14 and 15.

Kootenia convoluta Resser

Plate 41, figs. 17–24

1939a *Kootenia convoluta* Resser, p. 46, pl. 10, figs. 1–3, 7–11 (*non* figs. 4–6).

1939a *Kootenia maladensis* Resser, p. 47, pl. 10, figs. 12–15.

1939a *Kootenia granulosa* Resser, p. 47, pl. 10, figs. 16–20.

1939a *Kootenia nitida* Resser, p. 47, pl. 10, fig. 21.

1944 *Kootenia convoluta* Resser; Shimer and Shrock, p. 613, pl. 257, figs. 1–4.

Material. Six cranidia 9.4–13.8 mm. long and four pygidia 4.9–10.3 mm. long.

Description. Cranium moderately convex, length somewhat less than width across palpebral lobes. Glabella low for genus, parallel-sided, front broadly curved. Two sets of faint, broad glabellar furrows, both sets transverse. Palpebral area broadly convex, slightly downsloping. Palpebral lobes centred well posterior to glabellar midpoint, length approximately one-third that of glabella. Anterior border furrow shallow, very narrow and shallow in front of glabella; anterior border rolled downward and under cranium producing rounded appearance in side view. Posterior area as wide (tr.) as occipital ring. Occipital furrow rather narrow and of moderate depth. Occipital ring bears a spine.

Pygidium moderately convex, length–width ratio slightly less than 2:3. Axis consists of three rings and a rather long terminal piece. Pleural field broadly convex, marked by three distinct sets of pleural and two sets of interpleural furrows. Border gives rise to five sets of round, slightly uptilted spines. Entire surface of smallest pygidium and border and spines of all pygidia are granular. Surface of anterior border marked by terrace lines, front of glabella marked by short, irregular ridges. Remaining portions of medium-sized cranidia, pygidia, and of librigena, have definite pitted appearance.

Remarks. In describing specimens similar to these, Resser (1939a) recognized four species (see synonymy) from a single locality, based upon slight differences in ornamentation, relief, depth of furrows, and width of anterior border. The writer believes these differences should have been attributed to differences in preservation—with one exception. That is a cranium which Resser (pl. 10, figs. 4–6) placed under *Kootenia convoluta* and which more closely resembles *Kootenia crassinucha* sp. nov. Among the Campbell Ranch collections of *Kootenia*, only *K. convoluta* and *K. crassinucha* have pygidia bearing five sets of spines. The spines of *K. crassinucha* have a more swollen base and terminate in sharper, thorn-like points. Cranidia of *K. crassinucha* have glabellae that are more oval shaped in plan view and palpebral areas that are more strongly downsloping.

Occurrence. *Albertella* Faunizone, upper member, locality 71.

Kootenia crassa sp. nov.

Plate 42, figs. 23–27

1952 *Kootenia exilaxata* Deiss; Lochman, p. 125, pl. 26, figs. 1–20.*Material.* Four cranidia 1·8–6·9 mm. long and six pygidia 1·0–3·2 mm. long.

Description. Cranidium moderately convex, length approximately equal to width across palpebral lobes. Glabella rather low for genus, sides parallel to slightly divergent in forward direction, front broadly curved. Glabella marked by one short, shallow set of glabellar furrows that are inclined moderately toward rear. Palpebral area broadly curved and downsloping. Palpebral lobes one-third as long as glabella, centred opposite posterior one-third point on glabella. Anterior border flat, rather broad (exsag.) in front of anterior area, horizontal except for slight downwarp near ends. Posterior area not as wide (tr.) as occipital ring and traversed by a furrow of uniform depth and width. Occipital furrow deep at sides, shallow near axial midline; occipital ring narrow near ends, rapidly broadening (exsag.) toward axial midline.

Pygidium two-thirds as long as wide. Axis consists of three rings, a faint fourth, and terminal piece. Pleural field marked by three clear sets of pleural furrows and two faint sets of interpleural furrows. Border furrow wide and shallow; border weakly developed and bearing six sets of spines. All sets slightly divergent and flattened in cross-section, anterior set shorter than rest. Width of spines equals or slightly exceeds width of inter-spaces between. Surface of specimens worn, ornamentation indistinct except for terrace lines on anterior border of cranidium.

Remarks. A species described by Lochman (1952) from Sonora, Mexico as *Kootenia exilaxata* Deiss 1939 is considered to be conspecific with *K. crassa*. The only difference noted between the Sonora and Campbell Ranch material is that the pygidial spines of the Sonora specimens tilt less strongly upwards. Pygidia in both collections differ from the paratype of *K. exilaxata* Deiss in having a narrower axis and pygidial spines that are flat rather than round in cross-section. In the Campbell Ranch collections, *Kootenia aculacauda* sp. nov. is the only species that might be confused with *K. crassa*. *Kootenia aculacauda* differs from *K. crassa* in that its pygidium is less triangular in outline and the pygidial spines are shorter, narrower, and round in cross-section.

Occurrence. *Albertella* and *Glossopleura* Faunizones, upper member, localities 15 and 74.

Kootenia crassimucha sp. nov.

Plate 41, figs. 12–16

Material. Thirty-one cranidia 13·1–18·5 mm. long and three pygidia 11·5–12·3 mm. long.

Description. Cranidium moderately convex, length approximately four-fifths width across palpebral lobes. Glabella of moderate height, subparallel to slightly convex along sides, curvature medium at front and broad at back. One set of faint glabellar furrows located posteriorly on glabella and inclined back. Palpebral area convex and downsloping. Eye ridges broad and low. Palpebral lobes centred posterior to glabellar

midpoint, defined by a shallow furrow, length is between one-quarter and one-fifth that of glabella. Border furrow shallow; border narrow in front of glabella, wider and having a flat upper surface at sides. Posterior area rounded at distal end, width (tr.) considerably less than that of occipital ring. Margin of occipital furrow steep bordering glabella, moderate bordering occipital ring. Medial portion (sag.) of occipital ring tilted gently forward as does small occipital spine.

Pygidium moderately convex, length approximately three-quarters width. Axis composed of three rings and a rather long terminal piece. Pleural field marked by three pleural furrows and three low, narrow ridges; anterior two ridges originate between anterior and second axial ring, posterior ridge between second and third ring. Border moderately downsloping, bearing five sets of spines, swollen near base of each spine; spines taper rapidly and then extend into thin points. Surface of cranidium is worn and thus appears to be rather smooth; fine pits are sparsely scattered on palpebral area and pleural area of pygidium.

Remarks. These cranidia most resemble those of *Kootenia germana* Resser 1939a. However, they have palpebral areas which are not as wide, longer (sag.) occipital rings, and shorter occipital spines. Pygidia of *K. crassinucha* have five sets of spines while those of *K. germana* have six. *Kootenia convoluta* Resser 1939a, the only other five-spined *Kootenia* in the Campbell Ranch collections, differs from *K. crassinucha* in having a glabella that is more rectangular in outline and less rapidly tapering pygidial spines. The spines of *K. convoluta* do not produce a swelling on the border of the pygidium.

Occurrence. *Albertella* Faunizone, upper member, locality 71.

Kootenia sp. indet.

Plate 43, figs. 31, 32

Material. One damaged pygidium approximately 11·8 mm. long.

Description. Pygidium moderately convex; axis composed of three rings and a terminal piece. Pleural field of medium convexity, crossed by three pleural furrows. Border of average width, swollen near base of each marginal spine. Six sets of spines, size and spacing of posterior five is uniform. Surface of internal mould nearly smooth.

Remarks. Marginal spines of this species resemble those of *Kootenia crassinucha* sp. nov. in that they are of medium length and their base is associated with a swelling on the border. They differ from those of *K. crassinucha* in that they number six rather than five, and do not extend into slender points.

Occurrence. *Glossopleura* (?) Faunizone, upper member, locality 18.

Genus *OLENOIDES* Meek 1877

Type species. *Paradoxides? nevadensis* Meek 1877.

Olenoides steptoensis sp. nov.

Plate 39, figs. 1–8

Material. Four cranidia 5·8–19·4 mm. long and four pygidia 3·8–15·4 mm. long.

Description. Cranidium convex, slightly wider across palpebral lobes than long. Glabella parallel sided, curvature medium across front, length-width ratio a bit less than 4:3. Two weak sets of glabellar furrows, anterior set short, transverse, and located opposite glabellar midpoint, posterior set forked, one branch transverse and one inclined toward rear. Palpebral area convex, average slope slightly outward. Palpebral lobes centred posterior to glabellar midpoint. Anterior border back-sloping, width in front of glabella half that at sides. Posterior area nearly as wide (tr.) as axial ring, traversed by a wide furrow of medium depth. Occipital ring of moderate length (sag.) and bearing a spine.

Pygidium moderately convex, length-width ratio almost 2:3. Axis consists of four rings with nodes and terminal piece. Pleural field marked by three pleural furrows and a fourth (?) positioned almost against axis, three narrow interpleural furrows (third is bounded by sharp ridges), and one narrow ridge located against terminal piece. Border bears four sets of spines, posterior set directed straight back, other sets slightly divergent. Test covered with medium-size granules.

Remarks. Pygidia of *Olenoides maladensis* Resser 1939a most resemble these, but have smaller spines with the posterior pair spaced further apart. In the type lot containing *O. maladensis* are five unfigured cranidia of that species. Compared with *O. steptoensis*, they have a broader glabella, a narrower anterior border, and a shorter (sag.) occipital ring. In addition, the second set of glabellar furrows from the rear are situated further forward than on *O. steptoensis*. The five unfigured cranidia agree in every respect with a cranidium figured by Resser (1939a, pl. 14, fig. 3) as his holotype for *Taxioura magna* and are from the same locality. Palmer (1964b, pp. 6, 7) has correctly suggested that this cranidium belongs to *O. maladensis*.

Occurrence. Albertella Faunizone, upper member, localities 9 and 71.

Olenoides sp. indet.

Plate 43, figs. 20-23

Material. One cranidium 16.6 mm. long and one tentatively assigned hypostoma.

Description. Cranidium convex, length somewhat less than width across palpebral lobes. Glabella parallel sided, curvature medium in front. Two sets of glabellar furrows, anterior set short, transverse, and located opposite midpoint; posterior set forked with one branch inclined forward and one back. Palpebral area convex and downsloping. Eye ridges strong. Palpebral lobes start approximately opposite glabellar midpoint, length less than one-third that of glabella. Posterior area not as wide (tr.) as occipital ring, broadly pointed. Occipital ring short (sag.) and bearing a small spine. Tentatively assigned hypostoma strongly convex, median body ovoid in plan view, marked by very shallow maculae, border furrow narrow, posterior and postero-lateral border much wider than antero-lateral and anterior border, anterior wings small. Cranidium covered by granules of medium size; irregular ridges present on forward portion of glabella and on most of hypostoma.

Remarks. A wider glabella, more steeply dipping palpebral area, and a shorter (sag.) occipital ring distinguish this cranidium from those of *Olenoides steptoensis* sp. nov. The hypostoma tentatively placed with this large cranidium is also large and has a similar ornamentation. However, the anterior wings are relatively small for a dorypygid hypostoma.

Occurrence. *Glossopleura* (?) Faunizone, upper member, locality 18.

Family OGYGOPSIDAE Rasetti 1951

Genus OGYGOPSIS Walcott 1889

Type species. *Ogygia klotzi* Rominger 1888.

Ogygopsis sp. indet.

Plate 40, fig. 30

Material. One pygidial fragment 15.4 mm. long.

Description. Pygidial axis narrow, nearly cylindrical, sides slightly converging toward rear. Axis composed of at least seven rings, terminal piece, and short postaxial ridge fused to border. Each axial ring marked by a very shallow, transverse furrow that does not extend to axial furrow. Pleural field composed of six or more fused pleurae. Pleural furrows of medium width and depth; no interpleural furrows visible. Border narrow, well rounded in cross-section, curved posteriorly except for almost straight portion behind axis. Surface of pygidium nearly smooth except for faint, undulating ridges on border.

Remarks. This pygidium differs from that of *Ogygopsis typicalis* (Resser) 1939a [= *O. magna* (Resser) 1939a] in having narrower and shallower axial furrows, a wider terminal piece, and by lacking a medial notch on the posterior margin.

Occurrence. *Albertella* Faunizone, upper member, locality 11.

Family ORYCTOCEPHALIDAE Beecher 1897

Genus ORYCTOCEPHALUS Walcott 1886

Type species. *Oryctocephalus primus* Walcott 1886.

Oryctocephalus cf. *O. primus* Walcott

Plate 40, figs. 14–16

1886 *Oryctocephalus primus* Walcott, p. 210, pl. 29, figs. 3, 3a

1890 *Oryctophalus primus* Walcott; Walcott, p. 653, pl. 95, figs. 4, 4a.

1889 *Oryctocephalus primus* Walcott; Miller, p. 558, figs. 1036, 1037.

non 1935 *Oryctocephalus primus* Walcott; Kobayashi, pl. 15, fig. 1.

1954 *Oryctocephalus primus* Walcott; Palmer, p. 68, pl. 15, figs. 1, 2.

Material. One damaged cranidium.

Remarks. The cranidium that Walcott designated as a cotype for *Oryctocephalus primus* agrees closely with this one. Assignment of the present cranidium is questioned only because of its incompleteness. A slightly higher, more parallel-sided glabella and a narrower palpebral area served to distinguish the cranidium of *O. primus* from that of *Oryctocephalus maladensis* Resser 1939a.

Occurrence. Albertella Faunizone, upper member, locality 10.

Oryctocephalus maladensis Resser

Plate 41, figs. 25–27

1939a *Oryctocephalus maladensis* Resser, p. 45, pl. 3, figs. 7–9.

Material. Seven cranidia 3·1–4·1 mm. long.

Description. Cranidium low, longitudinal profile broadly convex, transverse profile averages horizontal, length–width ratio 3:4. Glabella subrectangular, low along margins and along transverse depressions between pits, slightly higher along remaining portion near axial midline. One set of short glabellar furrows located opposite origin of ocular ridge. Three sets of glabellar pits, longitudinal interspace distance equal between sets, same distance separates posterior set from two pits in occipital furrow, transverse interspace distance wider but likewise equal for glabellar and occipital pits. Axial furrow has uniformly moderate depth and width. Palpebral area wide, flat, and up-sloping. Ocular ridge low, outlined by a shallow furrow on either side. Palpebral lobes originate opposite anterior set of pits, length slightly exceeds half that of glabella. Anterior border narrow; anterior border furrow narrow and shallow. Posterior area half again as wide (tr.) as occipital ring, traversed by a furrow that broadens and deepens distally. Occipital ring bears a node located anterior to midpoint. Surface of cranidium nearly smooth, faint venation present on palpebral area.

Remarks. Cranidia of this species in the Campbell Ranch collections are nearly identical to the original types described by Resser from the '*Ptarmigania strata*' of southern Idaho.

Occurrence. Albertella Faunizone, upper member, locality 71.

Genus ORYCTOCEPHALITES Resser 1939

Type species. *Oryctocephalites typicalis* Resser 1939a.

Oryctocephalites typicalis Resser

Plate 41, figs. 9–11

1939a *Oryctocephalites typicalis* Resser, p. 45, pl. 3, figs. 1–6.

Material. Six cranidia 1·6–3·9 mm. long.

Description. Cranidium moderately convex in side view, broadly convex in front view, length approximately three-quarters width. Glabella moderately low, sides convex, narrowest at posterior margin, widest at midlength, broadly curved across front. Three

sets of glabellar pits, longitudinal spacing equal between sets, transverse spacing equal between anterior two sets, posterior set more closely spaced and joined by a furrow. Axial, anterior border, posterior border, and occipital furrows all moderately narrow and of medium depth. Eye ridges barely visible. Palpebral lobes upsloping, half as long as glabella, and terminating just ahead of occipital furrow. Anterior border of uniform width, bearing a node located slightly anterior to midpoint.

Occurrence. *Albertella* Faunizone, upper member, localities 71 and 11.

Family DOLICHOMETOPIDAE Walcott 1916
Genus ATHABASKIA Raymond 1928

Type species. *Athabaskia ostheimeri* Raymond 1928.

Athabaskia sp. indet.

Plate 43, figs. 1, 2

Material. Four broken pygidia estimated to be 1.9–4.3 mm. long and three tentatively assigned librigenae.

Description. Pygidium probably twice as wide as long. Axis consists of three rings bearing large nodes or spines, an indistinct fourth ring, and terminal piece. Pleural region convex across inner three-fifths, outer two-fifths concave. Pleural region marked by four pleural and interpleural furrows, all are of equal strength, all shallow abruptly and vanish before reaching margin of pygidium. Librigena with long eye platform, lateral border furrows deep and very broad, lateral border consists of turned up edge of test. Librigena and pygidium nearly smooth.

Remarks. The above material is too fragmentary for comparison with other species. It is figured and briefly described only to document the presence of the genus.

Occurrence. *Glossopleura* Faunizone, upper member, locality 74.

Genus BATHYURISCUS Meek 1873

Type species. *Bathyriscus? haydeni* Meek 1873.

Bathyriscus petalus sp. nov.

Plate 43, figs. 27–30

Material. Three cranidia 4.5–8.5 mm. long and three pygidia 5.1–6.9 mm. long.

Description. Cranidium moderately convex, length slightly greater than width across palpebral lobes. Glabella approximately twice as long as wide, sides parallel along posterior half, only slightly divergent along anterior half, broadly curved across front. Anterior three sets of glabellar furrows barely visible, posterior set shallow and inclined toward rear. Axial furrow shallow. Palpebral area moderately convex and downsloping. Palpebral furrow uniformly wide and shallow; palpebral lobes uniformly narrow, half

as long as glabella, terminating just ahead of occipital furrow. Fixigena immediately anterior to palpebral lobe much wider (tr.) than frontal area (sag.). Posterior area exceeds occipital ring in width (tr.). Occipital furrow broad and shallow; occipital ring bears a small spine on posterior margin.

Pygidium nearly twice as wide as long. Axis consists of four rings, terminal piece, and short postaxial ridge; a transverse ridge or node is present on each of the anterior three rings. Pleural field only slightly convex, marked by four strong pleural and four narrow interpleural furrows. Border upsloping, width uniform except for constriction near shallow posterior cusp and local extension into a set of short, antero-lateral spines. Scattered puncti present on occipital ring, remainder of test smooth.

Remarks. The combination of a long, narrow glabella and a wide pygidium with antero-lateral spines differentiates this species from others in the genus *Bathyriscus*. A single, small (2 mm.) pygidium, *Bathyriscus politus* Resser 1939a, resembles this species in many respects, but has a subtriangular outline and one less set of pleural and interpleural furrows. It is impossible to ascertain whether or not specific features are fully developed on this small pygidium.

Occurrence. *Glossopleura* (?) Faunizone, upper member, locality 18.

Genus CORYNEXOCHIDES Rasetti 1948

Type species. *Corynexochides gregarius* Rasetti 1948.

Corynexochides prolatus sp. nov.

Plate 42, figs. 7-11

Material. Seven cranidia 1.6-4.5 mm. long and one pygidium 0.9 mm. long.

Description. Cranidium convex, length approximately equal to width across palpebral lobes. Glabella cylindrical except for moderate expansion along anterior one-third, broadly curved across front. Two weak sets of glabellar furrows, anterior set short, transverse, located opposite glabellar midpoint, posterior set inclined toward rear. Palpebral area convex, downsloping. Palpebral lobes narrow, broadly curved along anterior half, extending nearly straight back along posterior half, terminating slightly forward of occipital furrow. Anterior area of fixigena uniformly narrow, width (tr.) approximately equals breadth (exsag.) of anterior border. Anterior border furrow of medium depth, deeper than axial furrow. Posterior area not as wide (tr.) as occipital ring, distal end rounded, furrow occupies nearly half of area. Occipital furrow straight and of medium depth, broadening near ends. Occipital ring expanded medially and bears an elongate (sag.) node.

Pygidium over twice as wide as long, lateral margins converge to points. Axis consists of one distinct ring, one faint ring, and terminal piece, latter two portions have a flattish surface on top. Pleural area moderately downsloping, marked by two pleural furrows. Border has same slope as pleural field, two sets of cusps present on postero-lateral margin. Test punctate.

Remarks. A close resemblance exists between this species and *Corynexochides bicensis* Rasetti 1948. The latter species differs in having a lower, broader glabella, a narrower anterior border, and broader palpebral lobes. Pygidia of *C. bicensis* are smaller, but in other respects similar to the one here assigned to *C. prolatus*.

Occurrence. *Glossopleura* Faunizone, upper member, localities 18 and 74.

Genus GLOSSOPLEURA Poulsen 1927

Type species. *Dolichometopus boccar* Walcott 1916.

Glossopleura sp. indet. 1

Plate 43, figs. 3, 4

Material. Two damaged pygidia estimated to be 8.5 and 10.8 mm. long and two tentatively assigned librigenae.

Description. Pygidium moderately convex. Axis probably consists of three to four faintly defined rings and terminal piece. Pleural field marked by one pleural furrow and two low ridges that are near first (anterior) interpleural position. Contact between pleural field and border poorly defined; border broadly convex, narrowing posteriorly, maximum width exceeds that of pleural field. Librigena has wide border that expands slightly in posterior direction. Anterior inner edge of lateral border nearly converges with eye platform. Genal spine drawn into a slender point. Surface of pygidium and librigena nearly smooth except for medium-spaced, thin, irregular terrace lines.

Remarks. Pygidia and librigena of this species and of *Glossopleura* sp. indet. 2 occur together in a single locality. Parts have been tentatively assigned using similarities in the strength and pattern of terrace lines as a principal guide. As the differences in this ornamentation are not pronounced, there is some possibility that the natural association of parts has been reversed.

Occurrence. *Glossopleura* Faunizone, upper member, locality 74.

Glossopleura sp. indet. 2

Plate 43, figs. 5, 6

Material. Five damaged pygidia estimated to be 1.8 to 9.2 mm. long and seven tentatively assigned librigenae.

Description. Pygidium low; axis wider than pleural field, consisting of approximately five poorly defined rings and terminal piece. Pleural field broadly convex, crossed by four broad, shallow, pleural furrows. Border concave, width expands in posterior direction. Librigena has wide border of uniform width and a broad, evenly tapering spine. Surface of pygidium and librigena slightly rough, border marked by closely spaced, thin, irregular ridges.

Remarks. Pygidia of this species differ from those of *Glossopleura* sp. indet. 1, in having a border that broadens (tr.) in the posterior rather than the anterior direction. The

pleural field of *G. sp. indet.* 1 is less deeply furrowed, the upper surface is smoother, and the border is ornamented by terrace lines which are spaced further apart.

Occurrence. *Glossopleura* Faunizone, upper member, locality 74.

Genus POLIELLA Walcott 1916

Type species. *Bathyriscus (Poliella) anteros* Walcott 1916.

Remarks. *Poliella* is a genus which needs reviewing and a clearer definition. At present it is being used for similar forms found in the *Plagiura-Poliella*, *Albertella*, and *Glossopleura* Faunizones. The holotype is the youngest known species and, unlike most of the other species assigned to *Poliella*, it is small (1.5 cm.), bears an occipital spine, and axial spines on each thoracic segment.

Poliella denticulata Rasetti

Plate 38, figs. 14–18

1951 *Poliella denticulata* Rasetti, p. 173, pl. 12, figs. 6–9.

1951 *Poliella* cf. *P. denticulata* Rasetti, p. 174, pl. 9, figs. 7, 8.

Material. Eighteen cranidia 1.3–5.1 mm. long and seven pygidia 1.3–4.0 mm. long.

Description. Cranidium moderately convex, length equal to width measured across palpebral lobes. Glabellar length nearly twice minimum width, sides almost parallel along posterior half, slightly expanding along anterior half, front broadly curved and nearly reaching front margin of cranidium. Glabellar furrows indistinct, all four sets probably branched, posterior branch on fourth set deepest and strongly inclined toward rear. Palpebral area downsloping, maximum width nearly two-thirds that of glabella. Frontal area very narrow. Posterior area of fixigena nearly parallel-sided along most of width (tr.), width exceeds that of occipital ring. Palpebral lobes and furrows narrow and well defined, lobes terminate opposite or slightly anterior to occipital furrow. Occipital ring bears a short spine.

Pygidium twice as wide as long. Axis consists of anterior ring with transverse ridge rather than node, second ring bearing small node, poorly defined third ring, and terminal piece. Pleural field marked by three pleural furrows and one weak interpleural furrow. Border of moderate width, bearing a short, flat spine on antero-lateral margins, three sets of small lobes, and a medial cusp. Test punctate.

Remarks. There is close agreement between these pygidia and those in the type collection of *Poliella denticulata* Rasetti 1951. Cranidia in the latter collection are distorted, but cranidia in a second collection, which Rasetti (1951) has identified as *Poliella* cf. *P. denticulata*, are not; these closely resemble cranidia from the Campbell Ranch section.

Occurrence. *Albertella* Faunizone, upper member, localities 8, 9, 71, 72, 11, 14, and 15.

Poliella germana (Resser)

Plate 37, figs. 1-9

- 1939a *Dolichometopsis comis* Resser, p. 33, pl. 4, fig. 24 lower left cranidium only (*non* figs. 22, 23).
1939a *Dolichometopsis potens* Resser, p. 36, pl. 6, figs. 17-20 (*non* figs. 21-23).
1939a *Ptarmigania agrestis* Resser, p. 39, pl. 7, figs. 1, 2.
1939a *Ptarmigania altilis* Resser, p. 40, pl. 7, figs. 3, 4 (*non* fig. 5).
1939a *Ptarmigania sobrina* Resser, p. 40, pl. 7, figs. 13 pygidium only, 14, 15 (*non* fig. 12).
1939a *Ptarmigania germana* Resser, p. 41, pl. 7, figs. 16-20.
1939a *Ptarmigania dignata* Resser, pl. 41, pl. 8, figs. 1, 2, 4-7 (*non* fig. 3).

Material. Twenty-seven cranidia 0.9-26.0 mm. long, thirty-five pygidia 2.3-10.0 mm. long, four librigenae, and three hypostomata.

Description. Cranidium low, length somewhat less than width across palpebral lobes. Glabella nearly parallel sided along posterior third, expanding forward along anterior two-thirds, front broadly curved and almost reaching forward edge of cranidium. Four sets of broad, shallow glabellar furrows, anterior two sets inclined forward, third set inclined back, fourth with short transverse branch and long posteriorly inclined branch. Palpebral area nearly flat to slightly convex, sloped moderately downward, width equals two-thirds minimum width of glabella. Palpebral lobes set somewhat below adjoining palpebral area, broad and flat, nearly horizontal, and terminating opposite front margin of occipital furrow; palpebral furrow shallow and poorly defined. Anterior border very narrow in front of glabella, wider and more obvious along antero-lateral margin of cranidium. Posterior area expands distally, width (tr.) approximately equals that of occipital ring. Occipital furrow shallow; occipital ring bears a small node. Librigena has border that is approximately two-thirds as wide as area between border furrow and eye platform. Hypostoma with medium body that is traversed by deep furrow, posterior lobe small, anterior lobe uniformly convex, border furrow locally wide on strong anterior wings.

Pygidium approximately twice as wide as long, anterior margin directed out from axis and slightly back, posterior margin broadly curved except for medial cusp. Axis consists of three rings, terminal piece, and postaxial ridge extending to margin; anterior ring has a low, transverse ridge rather than node. Pleural field marked by three distinct and one faint pleural furrow, all extend across weak border furrow and on to wide border. Test punctate, transverse ridges visible on occipital ring, venation present on librigenae.

Remarks. In the above synonymy are listed seven of Resser's species that the writer believes have been based upon differences in preservation and upon artificially mixed parts from other species. Here the foreign parts are removed and the remainder placed under *Poliella germana*. The present species concept is focused upon the holotype of *P. germana*, which is the best preserved cranidium among the types representing Resser's seven species. The cranidia in this case are considered more distinctive than the equally well-preserved pygidia.

Occurrence. *Albertella* Faunizone, upper member, localities 8-11, 71, and 72.

Poliella leipalox sp. nov.

Plate 38, figs. 22–28

Material. Sixty-one cranidia 2.4–15.4 mm. long, thirty-seven pygidia 1.5–8.5 mm. long, sixteen librigenae, nineteen hypostomata, and two incomplete thoracic regions.

Description. Cranidium very low, somewhat wider across palpebral lobes than long. Glabella nearly rectangular, slightly concave along sides, very slightly expanded anteriorly, front broadly curved. Pattern of glabellar furrows similar to that on *Poliella germana* (Resser) 1939a. Palpebral area broadly convex, gently downsloping, width a bit more to slightly less than two-thirds minimum glabellar width. Palpebral lobes set a little lower than adjacent area and terminating opposite anterior margin of occipital furrow. Palpebral furrow shallow. Fixigena anterior to eye ridge wide (tr.) for a dolichometopid and downsloping. Border and border furrow poorly differentiated on frontal area; area dips gently forward, more strongly so near axial midline. Posterior area expanded distally; occipital ring has a small node. Librigena has border half to less than half as wide as area between border furrow and eye platform. Hypostoma with medial body traversed by deep furrow, posterior lobe small, anterior lobe has strong medial (sag.) keel with steep flanks, antero-lateral border furrow wide, anterior border furrow slightly narrower and much deeper, anterior wings strong.

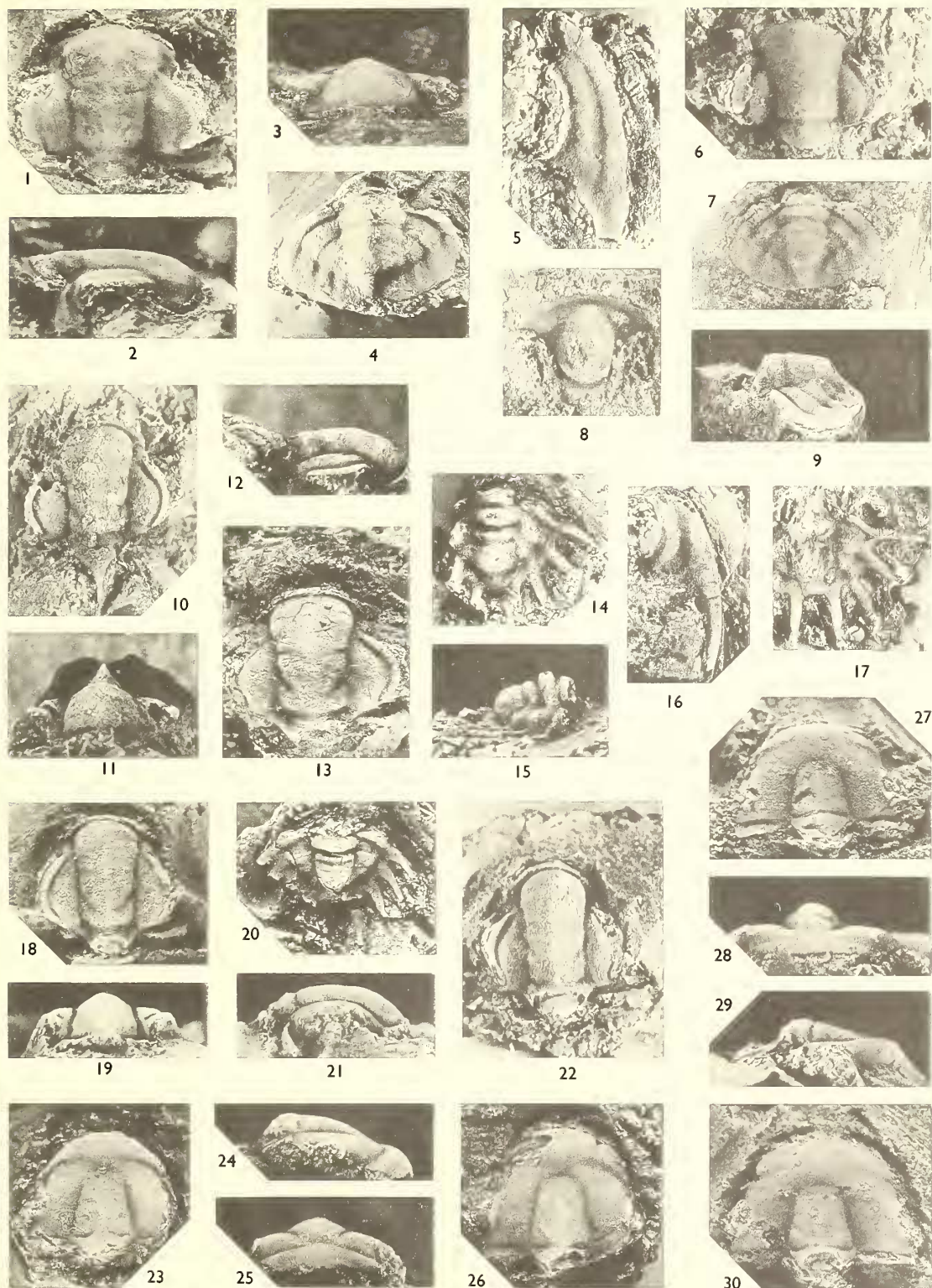
Pygidial width less than twice length. Axis consists of one ring with transverse ridge, terminal piece, and postaxial ridge. Anterior margin of pygidium begins to curve strongly back a short distance from axis, sides very strongly inclined toward rear, posterior margin broadly curved except for a medial cusp. Pleural field marked by three pleural furrows and one faint interpleural furrow. Border broad and poorly defined from pleural field. Test punctate, venation visible on librigenae, pygidium, and hypostoma.

Remarks. The most complete of two damaged thoracic regions in the above material shows a minimum of ten thoracic segments. *Poliella prima* (Walcott) 1916 resembles this species but has at least two less thoracic segments and a narrower palpebral area.

EXPLANATION OF PLATE 37

Olenellus and *Albertella* Faunizones.

- Figs. 1–9. *Poliella germana* (Resser) (p. 207). 1–3, Cranidium, plan, side, and front view, $\times 2.4$, USNM 153548, loc. 71. 4, 9, Pygidium, plan and side view, $\times 1.9$, USNM 153549, loc. 71. 5, Librigena, $\times 4.8$, USNM 153550, loc. 71. 6, Cranidium, small, $\times 7.2$, USNM 153551, loc. 71. 7, Pygidium, small, $\times 5.8$, USNM 153552, loc. 71. 8, Hypostoma, $\times 6.2$, USNM 153553, loc. 72.
- Figs. 10–17. *Ptarmiganoides araneicauda* sp. nov. (p. 209). 10–12, Paratype cranidium, plan, front, and side view, $\times 4.4$, USNM 153554, loc. 71. 13, Paratype cranidium, $\times 3.2$, USNM 153555, loc. 71. 14, 15, Holotype pygidium, plan and side view, $\times 3.5$, USNM 153556, loc. 9. 16, Paratype librigena, $\times 3.0$, USNM 153557, loc. 9. 17, Latex cast of paratype pygidium, $\times 1.9$, USNM 153558, loc. 71.
- Figs. 18–22. *Ptarmiganoides lepida*? (Resser) (p. 209). 18, 19, 21, Cranidium, plan, front, and side view, $\times 5.3$, USNM 153559, loc. 10. 20, Pygidium, partially peeled, $\times 3.9$, USNM 153560, loc. 12. 22, Cranidium, $\times 5.5$, USNM 153561, loc. 9.
- Figs. 23–26. *Crassifimbria walcotti*? (Resser) (p. 223). 23–25, Cranidium, plan, side, and front view, $\times 5.3$, USNM 153562, loc. 1085. 26, Cranidium, $\times 5.5$, USNM 153563, loc. 1085.
- Figs. 27–30. *Syspacephalus* sp. indet. (p. 226). 27–29, Cranidium, peeled, plan, front, and side view, $\times 6.2$, USNM 153564, loc. 1085. 30, Cranidium, peeled, $\times 6.2$, USNM 153565, loc. 1085.



Poliella germana (Resser) 1939a has a more rapidly expanding glabella, a narrower (sag.) frontal area, and a wider pygidium.

Occurrence. *Albertella* Faunizone, upper member, localities 8–12, 71, 72.

Genus PTARMIGANOIDES Rasetti 1951

Type species. *Ptarmiganoides bowensis* Rasetti 1951.

Ptarmiganoides araneicauda sp. nov.

Plate 37, figs. 10–17

Material. Sixty-eight cranidia 1·8–16·0 mm. long and twenty-eight pygidia 1·8–7·4 mm. long.

Description. Cranidium as wide or wider across palpebral lobes than long. Glabella moderately low, posterior half sub-parallel and somewhat concave along sides, anterior half expanded, front broadly curved. Four sets of glabellar furrows, anterior two sets inclined forward, third set curved back, last set with transverse branch and deep branch inclined back. Palpebral area upsloping, width exceeds half that of glabella at mid-length. Fixigena anterior to eye ridge narrow (tr.) but not as narrow (sag.) as anterior border. Posterior border broadens and flattens distally, bearing metafixigenal spine. Palpebral lobes strongly curved, positioned below level of adjacent fixigena and paralleled by a wide, deep palpebral furrow. Occipital ring tapers back for a considerable distance and extends into a spine. Librigena with spine wider than area between border furrow and eye platform.

Pygidium has high, wide axis consisting of three rings and terminal piece. Anterior ring tapers upward to form large spine. Pleural area downsloping, marked by one wide and two narrower pleural furrows. Border furrow nearly absent except for alignment of three sets of pits opposite interspaces between four sets of border spines. Spines approximately equal in size, widely spaced, nearly round in cross-section, anterior set almost normal to pygidial axis, posterior set almost parallel to axis. Test covered by granules of variable size.

Remarks. Pygidia of this species differ from those of *Ptarmiganoides lepida*? (Resser) 1939a, in having more widely spaced, round spines and deeper pits near the border. Cranidia differ in having a broader glabella that is less convex in cross-section.

Occurrence. *Albertella* Faunizone, upper member, localities 8–10, and 71.

Ptarmiganoides lepida? (Resser)

Plate 37, figs. 18–22

1939a *Dolichometopsis lepida* Resser, p. 31, pl. 3, figs. 31[?], 32, 33.

Material. Seventeen cranidia 0·9–8·0 mm. long and four pygidia 2·5–4·9 mm. long.

Description. Cranidium convex, length equal to or slightly greater than width across palpebral lobes. Glabella somewhat cylindrical, sides nearly parallel along posterior half, slightly expanded along anterior half, broadly curved across front, minimum width is approximately half glabellar length. Glabellar furrows arranged as on *Ptarmiganoides*

araneicauda sp. nov. Palpebral area slightly upsloping to horizontal, width approximately three-quarters minimum glabellar width. Palpebral lobes strongly curved, curvature along anterior half nearly as strong as along posterior half, elevation equals or is slightly less than that of area immediately across deep palpebral furrow. Posterior area almost as broad (tr.) as occipital ring and bearing a metafixigenal spine. Occipital ring drawn back into a spine that is inclined moderately upward.

Pygidium considerably wider than long. Axis moderately high, composed of an anterior ring bearing a large spine, two additional rings, and terminal piece. Pleural field marked by one wide and two narrower pleural furrows and set of faint ridges near anterior and near second interpleural position. Three sets of shallow pits on poorly defined border furrow. Four sets of flattened border spines, each set slightly larger than next anterior set. Area between spines nearly uniform except wider between posterior two. Test covered with medium to coarse granules.

Remarks. The holotype cranidium of *Dolichometopsis lepida* Resser 1939a agrees closely with cranidia in the present collection. Unfortunately, no associated pygidia were found in the type collection for comparison. Because many dolichometopid cranidia, and zacanthoidid cranidia as well, are known to be similar, the present assignment must be questioned.

Occurrence. *Albertella* Faunizone, upper member, localities 8–10 and 12.

Ptarmiganoides sp. indet.

Plate 38, figs. 19–21

Material. Five cranidia 7.2–13.1 mm. long.

Description. Cranidial length slightly exceeds width measured across palpebral lobes. Glabella nearly parallel-sided, very slightly concave along posterior two-thirds, slightly

EXPLANATION OF PLATE 38

Albertella Faunizone.

Figs. 1–7. *Albertelloides mischi* gen. et sp. nov. (p. 215). 1–3, Paratype cranidium, small, plan, front, and side view, $\times 7.2$, USNM 153566. 4, Paratype pygidium, small, $\times 2.5$, USNM 153567. 5, 7, Holotype pygidium, side and plan view, $\times 1.6$, USNM 153568. 6, Paratype cranidium, $\times 1.1$, USNM 153569. All specimens from loc. 12.

Figs. 8, 9. *Pagetia resseri* Kobayashi (p. 192). 8, Cranidium, $\times 11.6$, USNM 153570, loc. 72. 9, Pygidium, $\times 11.6$, USNM 153571, loc. 9.

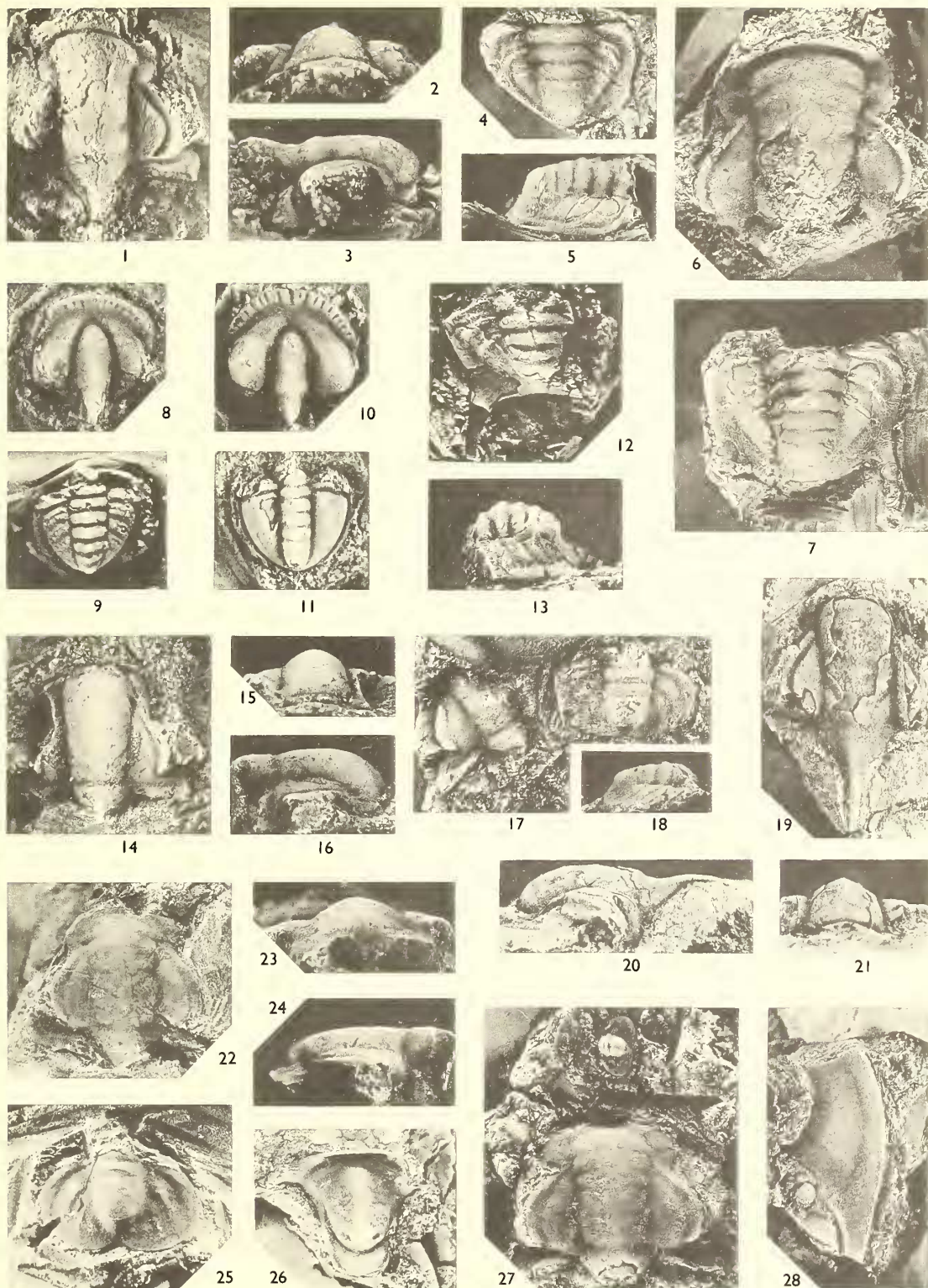
Figs. 10, 11. *Pagetia clytia* Walcott (p. 189). 10, Cranidium, $\times 9.7$, USNM 153572, loc. 72. 11, Pygidium, $\times 9.7$, USNM 153573, loc. 72.

Figs. 12, 13. *Albertelloides* sp. indet., gen. nov. (p. 217). Pygidium, partially peeled, plan and side view, $\times 3.1$, USNM 153574, loc. 9.

Figs. 14–18. *Poliella denticulata* Rasetti (p. 206). 14–16, Cranidium, plan, front, and side view, $\times 5.1$, USNM 153575, loc. 72. 17, 18, Pygidium, plan and side view; note partial cranidium in 17, $\times 4.5$, USNM 153576, loc. 71.

Figs. 19–21. *Ptarmiganoides* sp. indet. (p. 210). Cranidium, partially peeled, plan, side, and front view, $\times 3.4$, USNM 153577, loc. 8.

Figs. 22–28. *Poliella leipalox* sp. nov. (p. 208). 22–24. Paratype cranidium, plan, front, and side view, $\times 2.4$, USNM 153578, loc. 11. 25, Paratype pygidium, $\times 2.8$, USNM 153579, loc. 72. 26, Paratype hypostoma, $\times 2.9$, USNM 153580, loc. 11. 27, Holotype cranidium; note small pygidium, $\times 3.1$, USNM 153581, loc. 72. 28, Paratype librigena, $\times 2.5$, USNM 152582, loc. 72.



expanded along anterior third, front broadly rounded, length twice minimum width. Glabellar furrows have pattern as on *Ptarmiganoides araneicauda* sp. nov. except posterior set does not branch and is more strongly inclined toward rear. Palpebral area upsloping, a little less than two-thirds as wide as minimum width of glabella. Palpebral lobes moderately curved and terminating slightly anterior to point opposite occipital furrow. Occipital ring tapers back for a considerable distance before forming a spine. Cranidia covered with granules of varying sizes.

Remarks. These cranidia differ from those of *Ptarmiganoides araneicauda* sp. nov. and *Ptarmiganoides lepida*? (Resser) 1939a in having glabellae with less forward expansion, unbranched and strongly inclined posterior glabellar furrows, narrower palpebral areas, longer (sag.) occipital rings, and palpebral lobes that terminate ahead of the occipital furrow.

Occurrence. *Albertella* Faunizone, upper member, localities 8 and 71.

Family ZACANTHOIDIDAE Swinnerton 1915

Genus ZACANTHOIDES Walcott 1888

Type species. *Olenoides typicalis* Walcott 1886.

Zacanthoides demissus sp. nov.

Plate 42, figs. 1–6

Material. Six cranidia 4.6–12.3 mm. long and five pygidia 2.5–6.6 mm. long.

Description. Cranidium moderately convex, length equals width across palpebral lobes. Glabella rather low, parallel-sided, broadly curved across front. Anterior two sets of glabellar furrows indistinct; posterior two sets angle back, third set does not reach shallow axial furrow. Palpebral area flat and nearly horizontal. Palpebral lobes upsloping, originating against axial furrow, length exceeds three-quarters that of glabella. Facial suture strongly divergent from palpebral lobes forward; anterior limb wide and long. Posterior area narrow, width (tr.) exceeds that of occipital ring. Occipital furrow deep near ends, shallows and widens one-quarter furrow length in from ends, very shallow medially. Occipital ring bears a small spine.

Pygidial length slightly exceeds three-quarters width. Axis high, consisting of three rings, terminal piece, and steep postaxial ridge extending to margin. Pleural region flat and horizontal, marked by one faint interpleural and two pleural furrows. Three sets of broad, flat spines on posterior margin, sets decrease rapidly in size inward, all spines point slightly inward and are tilted gently downward. Test covered by small granules.

Remarks. Combined features that serve to differentiate this species from others in the genus *Zacanthoides* are a very wide and long (tr. and sag.) anterior limb on the cranidium and three sets of broad, flat, pygidial spines.

Occurrence. *Glossopleura* (?) Faunizone, upper member, locality 18.

Zacanthoides sp. indet.

Plate 40, figs. 7-10

Material. One cranium and one pygidium estimated to be 13.1 mm. and 4.6 mm. long respectively.

Description. Cranium slightly longer than wide across palpebral lobes. Glabella parallel-sided, front has medium curvature. Two sets of glabellar furrows, both sets angle back. Palpebral area moderately convex, averaging horizontal. Palpebral lobes originate at axial furrow, terminate opposite occipital furrow, length approximately three-quarters that of glabella. Facial suture strongly divergent from palpebral lobes forward. Occipital ring probably bears a spine.

Pygidium approximately two-thirds as long as wide. Axis consists of four rings and a terminal piece. Pleural field marked by three sets of furrows which terminate between four sets of spines. Spines round to elliptical in cross-section, directed slightly inward and downward; very small additional spines may be present behind axis. Test covered by small granules.

Remarks. This material is too poorly preserved for specific identification. There is little question, however, that it represents a species different from *Zacanthoides demissus* sp. nov., as the cranium has a narrower (tr.) palpebral area and the pygidium has more numerous, round spines.

Occurrence. *Albertella* Faunizone, upper member, locality 15.

Genus ALBERTELLA Walcott 1908

Type species. *Albertella helena* Walcott 1908.

Albertella judithi sp. nov.

Plate 39, figs. 22-30

Material. Seventy crania 2.3-10.0 mm. long and seventy-two pygidia 1.5-13.1 mm. long.

Description. Cranium as wide or slightly wider across palpebral lobes than long. Glabella nearly cylindrical, sides straight and slightly converging, front well rounded. Four sets of glabellar furrows, anterior and second set inclined moderately forward, third set inclined back, posterior set forks into nearly obsolete anterior branch and posterior branch that is inclined toward rear. Palpebral area flat, slightly upsloping, maximum width nearly four-fifths width of glabella at base. Palpebral lobes raised above adjacent palpebral area and terminating well posterior to occipital furrow; palpebral furrow narrow. Anterior limb tilted moderately upward along forward edge of cranium. In addition to ocular ridge, a second, weaker ridge originates in depression near antero-lateral margin of glabella; the latter ridge curves forward and outward to terminate at antero-lateral margin of cranium. Posterior area narrow and as wide (tr.) as occipital ring. Occipital ring has medial (sag.) ridge terminating in a short spine. Librigena has ridge originating on posterior portion of border and continuing along genal spine. Hypostoma with small, abrupt swelling paralleling and just posterior to maculae, antero-lateral and anterior border furrows shallow.

Pygidial length equal to width at base of spines. Axis consists of six rings and a terminal piece. Rings uniformly decrease in size except for relatively short (sag.) posterior ring; each bears a spine with a round basal cross-section. Anterior half of pleural field marked by two sharp ridges just behind anterior and second interpleural position, and two weaker ridges just ahead of these positions; posterior half of field marked by four weak ridges. Border posterior to spines is uniform in width and drops slightly in elevation near terminal piece. Border spines are uniformly narrow, horizontal, slightly divergent, and at least three-quarters as long as pygidium. Test covered by small granules; venation present on pygidium, particularly apparent on and near terminal piece.

Remarks. This species resembles *Albertella limbata* Rasetti 1951. It differs in having a glabella that converges rather than expands forward, an anterior border that slopes backward rather than forward, and glabellar furrows that are shallower. The pygidium differs by having one less axial ring, and border spines that are directed slightly outward rather than straight back.

Occurrence. *Albertella* Faunizone, upper member, localities 9, 10, 12, 71, and 72.

Albertella eiloitys sp. nov.

Plate 39, figs. 16–18

Material. Twelve pygidia 3.2–6.3 mm. long.

Description. Cranidium probably similar to that of *Albertella judithi* sp. nov.

Pygidial length exceeds width measured just anterior to border spines; entire pygidium posterior to spines slopes moderately toward rear. Axis consists of six rings and terminal piece, five rings bear spines with transversely ovate cross-sections at base, posterior ring has smaller spine or node. Pleural field narrow, marked by two sharp ridges near anterior and second interpleural position and by two or three similar but weaker ridges further back. Border tilted inward along postero-lateral margin of pygidium giving an 'upcurled' appearance. Border spines inclined upward and slightly outward, length unknown. Cranidium probably covered by small granules, pygidium nearly smooth except for venation on and near base of terminal piece.

Remarks. Cranidia of this species are thought to resemble those of *Albertella judithi* sp. nov. so closely that they cannot be differentiated. A second possibility, considered less likely, is that only cranidia of *A. judithi* are in the collections. Pygidial borders of *A. eiloitys* from two localities tilt inward, and therefore this feature cannot be attributed to distortion. In other respects, pygidia of *A. eiloitys* resemble those of *Albertella bosworthi* Walcott 1908 and *Albertella declevis* Rasetti 1951. If the first of the assumptions concerning the cranidia of *A. eiloitys* is correct, they differ from those of *A. bosworthi* and *A. declevis* in having a wider (tr.) anterior limb.

Occurrence. *Albertella* Faunizone, upper member, localities 9 and 11.

Albertella lata sp. nov.

Plate 39, figs. 19–21

Material. Five pygidia 3·1–7·5 mm. long.

Description. Pygidium low, wider than long. Axis strongly tapered, consisting of six rings and terminal piece, anterior five rings bear spines with round basal cross-sections. Pleural field low but slightly higher than border, traversed by two sharp ridges originating between anterior three rings and by several very weak ridges further back. Border flat and nearly horizontal, tilted moderately outward and broadly curved across rear of pygidium. Border spines located far back, horizontal and slightly divergent. Pygidium may be granular (surface preservation poor).

Remarks. A low relief, posteriorly located spines, and a broad curvature of the border between spines differentiate these pygidia from those of other species in this genus.

Occurrence. Pioche Shale, upper member, localities 10 and 71.

Genus ALBERTELLOIDES gen. nov.

Type species. *Albertelloides mischli* gen. et sp. nov.

Description. Cranium convex, approximately as wide across palpebral lobes as long. Glabella expands anteriorly, broadly curved across front, marked by four sets of glabellar furrows. Anterior border uniformly narrow. Palpebral area convex, at least half as wide as minimum glabellar width. Palpebral lobes narrow, set below level of adjacent palpebral area, length approximately half that of glabella. Eye ridges prominent and narrow. Posterior area narrow (exsag.) and bearing a metafixigenal spine. Occipital ring triangular in plan view and terminating in a spine. Thoracic section unknown.

EXPLANATION OF PLATE 39

Albertella Faunizone.

Figs. 1–8, *Olenoides steptoensis* sp. nov. (p. 199). 1–3, Paratype cranium, small, plan, front, and side view, $\times 3\cdot7$, USNM 153583. 4–6, Holotype pygidium, rear, side, and plan view, $\times 3\cdot3$, USNM 153584. 7, Paratype pygidium, $\times 3\cdot8$, USNM 153585. 8, Paratype cranium, $\times 2\cdot5$, USNM 153586. All specimens from loc. 71.

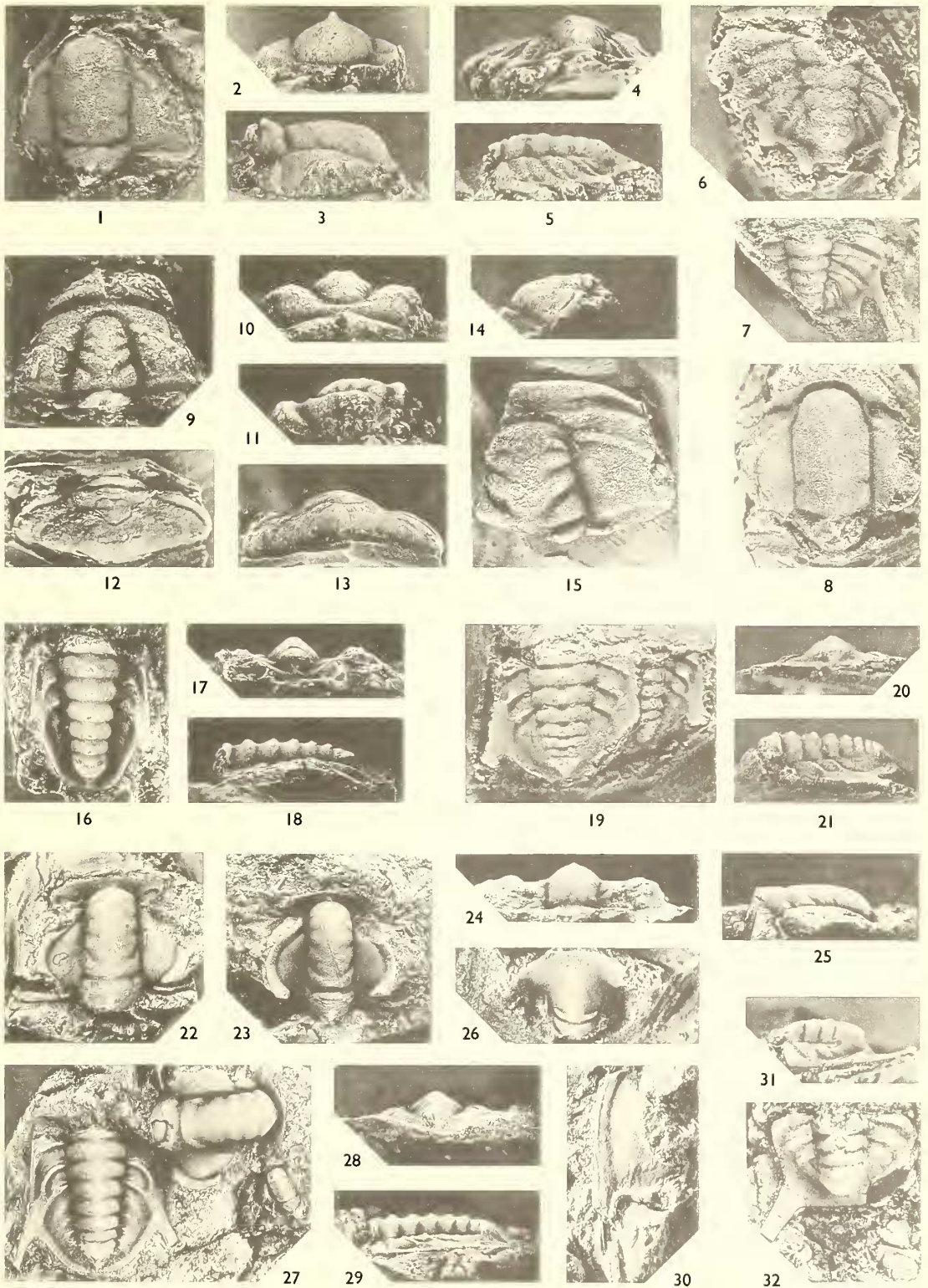
Figs. 9–15, *Caborcella graiosa* (Resser) (p. 221). 9–11, Cranium, plan, front, and side view, $\times 4\cdot0$, USNM 153587, loc. 9. 12–14, Pygidium, plan, rear, and side view, $\times 4\cdot5$, USNM 153588, loc. 11. 15, Partial cranium, large, $\times 1\cdot7$, USNM 153589, loc. 12.

Figs. 16–18, *Albertella eiloitys* sp. nov. (p. 213). Holotype pygidium, plan, rear, and side view, $\times 4\cdot2$, USNM 153590, loc. 11.

Figs. 19–21, *Albertella lata* sp. nov. (p. 214). Holotype pygidium, plan, rear, and side view; note second pygidium under holotype in fig. 19; $\times 3\cdot7$, USNM 153591, loc. 10.

Figs. 22–30, *Albertella judithi* sp. nov. (p. 212). 22, 24, 25, Paratype cranium, plan, front, and side view, $\times 2\cdot3$, USNM 153592. 23, Paratype cranium, $\times 3\cdot9$, USNM 153593. 26, Paratype hypostoma, $\times 4\cdot5$, USNM 153594. 27–29, Holotype pygidium, plan, rear, and side view; note two cranidia of the species in fig. 27; $\times 2\cdot2$, USNM 153595. 30, Paratype librigena, $\times 2\cdot5$, USNM 153596. All specimens from loc. 71.

Figs. 31, 32, *Albertelloides pandispinata* gen. et sp. nov. (p. 216). Holotype pygidium, side and plan view; note two pygidia of *Pagetia resseri* in fig. 32; $\times 5\cdot0$, USNM 153597, loc. 9.



Pygidium considerably wider than long, highly convex. Axis well elevated, extending back to border, consisting of approximately four or five rings and terminal piece. Pleural field convex, traversed by at least several sets of narrow ridges located near interpleural position. Border of medium width, giving rise to two marginal spines in postero-lateral position. Posterior margin between spines is moderately convex to nearly straight.

Remarks. *Albertella* is the genus which most closely resembles *Albertelloides*. Cranidia of most, but by no means all, specimens of *Albertella* differ from the three cranidia thus far assigned to the new genus by having (1) a narrower (tr.) anterior limb, (2) a glabella with less expansion along the anterior half and a more rounded front, (3) palpebral areas that are less convex in cross-section (tr.), and (4) palpebral lobes that are broader. Pygidia of most specimens of *Albertella* differ from those of *Albertelloides* in having (1) a lower axis, (2) pleural fields that are less convex, (3) axial rings that bear spines, and (4) marginal spines that are located further forward. No species of *Albertella* is known to have attained as large a size as *Albertelloides mischi* or to possess metafixigenal spines. Nearly all species of *Albertella* have a granular test while those belonging to *Albertelloides* do not.

Of the five species known to belong to *Albertelloides*, three, *A. mischi*, *A. pandispinata*, and *A. sp. indet.* are described in this paper. The fourth and fifth are known from pygidia described by Resser (1919a) as *Kochaspis dispar* and *Kochaspis maladensis*. Cranidia which Resser wrongly assigned to *K. dispar* probably belong to the genus *Caborcella*.

Occurrence. Upper member of the Pioche Shale in the Campbell Ranch section, and 'Ptarmigania strata' of southern Idaho. Both localities are believed to be in the later portion of the *Albertella* Faunizone.

Albertelloides mischi gen. et sp. nov.

Plate 38, figs. 1-7

Material. Three cranidia 4.2-21.2 mm. long and three pygidia 7.2-13.5 mm. long.

Description. Cranidium convex, length approximately equal to width across palpebral lobes. Glabellar sides straight and parallel along posterior half, diverging along anterior half, front broadly curved, crest outlined in side view is evenly curved from front to back. Four sets of shallow glabellar furrows, anterior two sets inclined forward, third set inclined back, fourth set branched with both limbs inclined back. Axial furrow of uniform depth and width except for set of small pits just anterior to eye ridges and small swellings ahead of pits. Palpebral area moderately convex, tilted slightly inward. Eye ridges swept strongly back, width approximately same as that of palpebral lobes. Palpebral lobes narrow, set below level of adjacent palpebral area, terminating opposite or just posterior to occipital furrow. Anterior area of fixigena wider (tr.) than anterior border is long (sag.); facial suture slightly divergent from palpebral lobes to anterior border furrow. Anterior border of uniformly narrow width and tilted back. Posterior area broadens distally and bears metafixigenal spine. Occipital furrow of uniform width and depth; occipital ring drawn back into a spine.

Pygidium convex, much wider than long, greatest width just posterior to strongly curved antero-lateral margins, from these points lateral margins are nearly straight and slightly

converging until reaching marginal spines, posterior margin broadly and evenly curved. Axis high, extending to border, composed of five or six rings and terminal piece. Pleural field convex, downsloping, marked by four narrow ridges, anterior two closely spaced near first (anterior) interpleural position, posterior two similarly spaced near second position and weaker. Border furrow shallow; border moderately downsloping at sides of pygidium, steeply downsloping along back. Spines located postero-laterally, slightly divergent, and tilted moderately upward. Surface of test nearly smooth except for venation that is most noticeable on border of pygidium and on palpebral area.

Remarks. Pygidia of *Albertelloides dispar* (Resser) 1939a resemble those of this species but have a wider pleural field and only three to four distinct axial rings.

Occurrence. *Albertella* Faunizone, upper member, locality 12.

Albertelloides pandispinata gen. et sp. nov.

Plate 39, figs. 31, 32

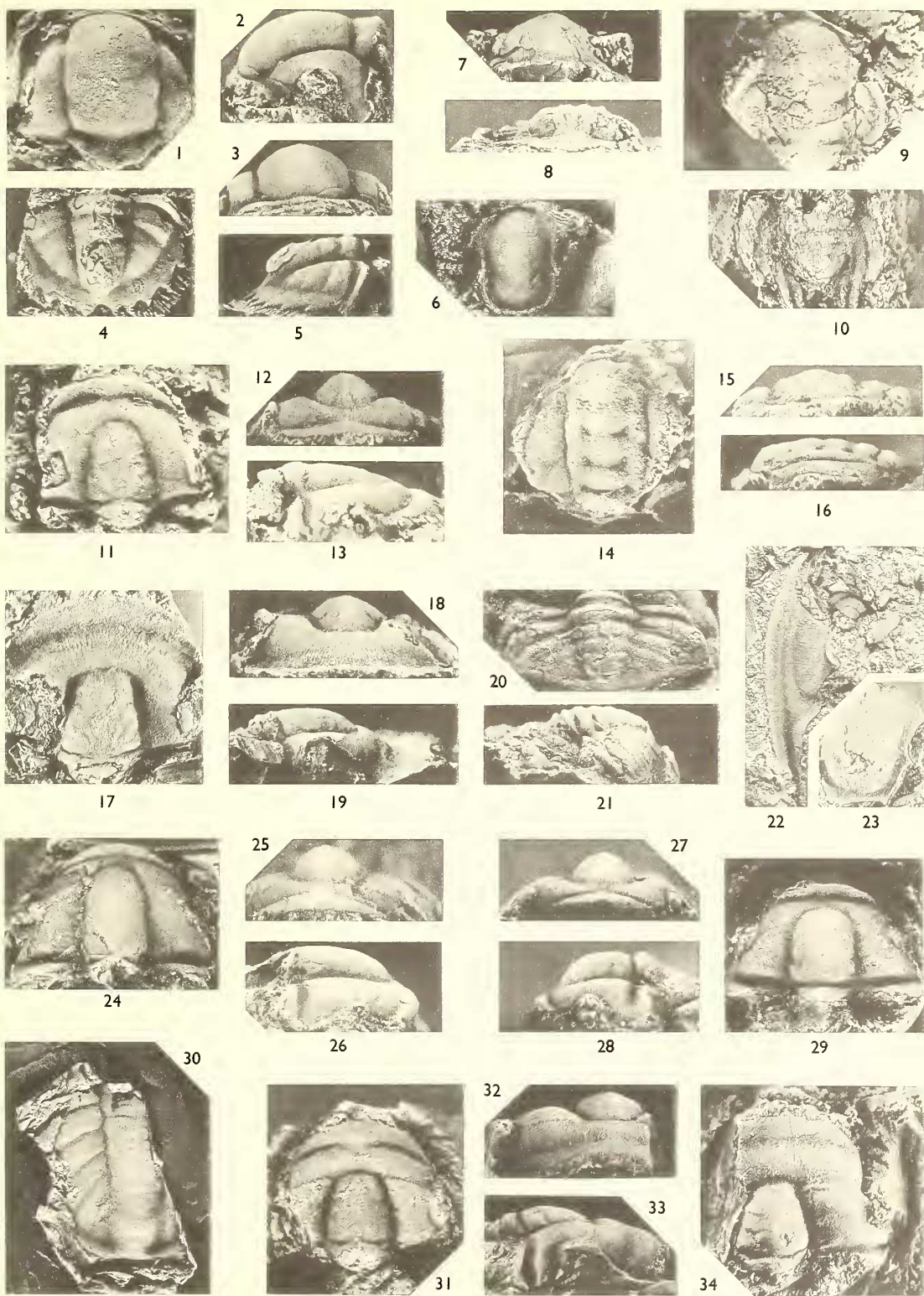
Material. Two pygidia, each 9.0 mm. long.

Description. Pygidium approximately two-thirds as long as wide. Axis nearly cylindrical, slightly tapered toward rear, composed of four rings and terminal piece, furrows between rings widen near middle. Pleural field slopes moderately outward, abruptly steepens near border, marked by two sets of sharp ridges near first (anterior) and second interpleural position. Border widest and locally horizontal near spines, steeply downsloping between spines, posterior margin straight. Spines flattish, strongly divergent, tilted slightly upward. Ornamentation unknown (pygidium is worn).

EXPLANATION OF PLATE 40

Albertella Faunizone.

- Figs. 1–6. *Kootenia brevispina* Resser (p. 196). 1–3, Paratype cranium, plan, side, and front view, $\times 2.3$, USNM 153598, loc. 14. 4, 5, Holotype pygidium, plan and side view, $\times 2.2$, USNM 153599, loc. 14. 6, Paratype hypostoma, $\times 2.7$, USNM 153600, loc. 15.
- Figs. 7–10. *Zacanthoides* sp. indet. (p. 212). 7, 9, Cranium, front and plan view, $\times 2.8$, USNM 153601, loc. 15. 8, 10, Pygidium, side and plan view, $\times 3.6$, USNM 153602, loc. 15.
- Figs. 11–13. *Pachyaspis gallagari* sp. nov. (p. 231). Holotype cranium, plan, front, and side view, $\times 6.0$, USNM 153603, loc. 14.
- Figs. 14–16. *Oryctocephalus* cf. *O. primms* Walcott (p. 201). Cranium, plan, front, and side view, $\times 6.5$, USNM 153604, loc. 10.
- Figs. 17–23. *Amecephalus laticandum* (Resser) (p. 227). 17–19, Cranium, plan, front, and side view, $\times 2.3$, USNM 153605, loc. 14. 20, 21, Pygidium, plan and side view, $\times 3.7$, USNM 153606, loc. 15. 22, Librigena, $\times 2.9$, USNM 153607, loc. 18. 23, Partial hypostoma, $\times 2.9$, USNM 153608, loc. 15.
- Figs. 24–26. *Pachyaspis longa* sp. nov. (p. 231). Holotype cranium, plan, front, and side view, $\times 6.5$, USNM 153609, loc. 11.
- Figs. 27–29. *Spencia quadrata* sp. nov. (p. 232). Holotype cranium, front, side, and plan view, $\times 7.9$, USNM 153610, loc. 11.
- Fig. 30. *Ogygopsis* sp. indet. (p. 201). Latex cast of partial pygidium, $\times 1.8$, USNM 153611, loc. 11.
- Figs. 31–34. *Chancia venusta* (Resser) (p. 230). 31, Cranium, small, peeled, $\times 5.0$, USNM 153612, loc. 12. 32–34, Cranium, peeled, front, side, and plan view, $\times 2.3$, USNM 153613, loc. 12.



Remarks. This species most resembles *Albertelloides unaladensis* (Resser) 1939a, but has four rather than three axial rings, a straight rather than broadly curved posterior margin, and marginal spines that are more strongly divergent.

Occurrence. *Albertella* Faunizone, upper member, locality 9.

Albertelloides sp. indet.

Plate 38, figs. 12, 13

Material. One pygidial fragment estimated to be 6.2 mm. long.

Description. Pygidium very convex. Axis high, consisting of four rings and terminal piece, furrows between rings widen near axial midline. Pleural field convex, steeply down-sloping, marked by four narrow ridges, anterior two closely spaced near first (anterior) interpleural position, posterior two weaker and similarly arranged near second position. Border slopes gently outward. Spines horizontal, elliptical in cross-section, slightly divergent near base, gently curved and less divergent further out. Posterior margin of pygidium slightly concave inward. Surface of pygidium poorly preserved, ornamentation unknown.

Remarks. Compared to *Albertelloides paudispinata* sp. nov., this species has a higher axis, more steeply sloped pleural field, and spines which are less divergent.

Occurrence. *Albertella* Faunizone, upper member, locality 9.

Genus ZACANTHOPSIS Resser 1938

Type species. *Olenoides levis* Walcott 1886.

Zacanthopsis levis (Walcott)

Plate 36, figs. 11–14

- 1886 *Olenoides levis* Walcott, p. 187, pl. 25, figs. 3, 3a.
- 1888 *Zacanthoides levis* Walcott; Walcott, p. 165.
- 1891 *Zacanthoides levis* Walcott; Walcott, p. 646, pl. 94, figs. 5, 5a.
- 1906 *Zacanthoides?* *levis* Walcott; Lorenz, p. 72, 1 text-fig.
- 1938b *Zacanthopsis levis* (Walcott); Resser, p. 106, pl. 3, figs. 40, 41.
- 1964b *Zacanthopsis levis* (Walcott); Palmer, pl. 3, figs. 1–3.

Material. Thirty-six cranidia 3.1–6.7 mm. long.

Description. Glabella nearly cylindrical, anterior portion slightly expanded, front broadly rounded. Three sets of shallow glabellar furrows, anterior set short, second and third sets inclined back, third set joining. Palpebral area horizontal, nearly flat, as wide or wider than glabella at midpoint. Anterior border furrow broad; anterior border steeply back-sloping. Eye ridges of weak to medium strength; palpebral furrows narrow; palpebral lobes raised above adjacent area and slightly longer than half glabellar length. Posterior border nearly normal to axis, bends abruptly forward and downward at point just posterior to palpebral lobe. Occipital furrow expands near ends, otherwise of

medium width and depth. Occipital ring set below level of glabella, triangular in plan view, drawn back into spine that has small node at base. Top and undersurface of cranium covered by fine granules.

Occurrence. Upper *Olenellus* Faunizone, lower member, localities 2, 3, and 1085.

Order PTYCHOPARIIDA Swinnerton 1915

Family PTYCHOPARIIDAE Matthew 1887

Genus ACHLYSOPSIS gen. nov.

Type species. *Achlysopsis liokata* gen. et sp. nov.

Description. Cranium moderately low, very lightly furrowed, broadly curved in both directions, length approximately equal to width across palpebral lobes. Glabella low, particularly so in front, length and width about equal, sides converge forward, front moderately rounded. Glabellar front and preglabellar field slope forward at approximately same angle, forward slope of flat anterior border is less steep. Length (sag.) of preglabellar field slightly greater than that of anterior border. Palpebral area broadly curved, averages horizontal to slightly downsloping, approximately half as wide as maximum glabellar width. Palpebral lobes narrow, centred posterior to glabellar midpoint, approximately half as long as glabella. Posterior area not as wide (tr.) as occipital ring, rounded at distal end. Occipital ring short (sag.), low, bearing a node.

Tentatively assigned pygidium is small, transverse, and convex. Axis low, narrow, composed of approximately six rings and terminal piece. Pleural region comprised of six or seven fused segments that slope gently outward near axis and rather steeply outward near margin, both pleural and interpleural furrows visible.

Remarks. Crania of this genus closely resemble those in the genus *Mexicella*. They differ from the type species, *Mexicella mexicana* Lochman 1952, in having a lower glabella, shallower dorsal furrow, larger and more posteriorly located palpebral lobes, and by lacking a boss on the preglabellar field. *Mexicella stator* (Walcott) 1916 occupies a more intermediate position between the two genera as it has a low glabella and lacks a boss. Pygidia tentatively assigned to *Achlysopsis* have a narrower axis with far more segments than those belonging to *Mexicella*. A second genus, *Onchocephalites* Rasetti 1957, resembles *Achlysopsis* in its general appearance and in having very shallow cranial furrows. *Onchocephalites* differs from *Achlysopsis* in having a glabella with convex lateral margins, facial sutures that turn sharply inward after crossing the anterior border furrow, and an anterior border that slopes more steeply forward. *Nanogia* Poulsen 1964 also resembles *Achlysopsis*, but has a glabella with concave lateral margins, palpebral lobes that are located in a more posterior position, and facial sutures that are strongly divergent from the palpebral lobes forward. The only known species of *Achlysopsis* are the two described in the present paper. If the pygidium tentatively assigned to the type species proves to be the correct one, then a similar pygidium described as *Tonkinella idahoensis* Resser 1939a may represent a third species.

Occurrence. Upper member of the Pioche Shale, Campbell Ranch section. In this section the genus ranges from the late *Albertella* into the early *Glossopleura* (?) Faunizone.

Achlysopsis liokata gen. et sp. nov.

Plate 42, figs. 17–22

Material. Thirty-eight cranidia 1·8–9·2 mm. long and two tentatively assigned pygidia 1·5 and 3·8 mm. long.

Description. Cranidium moderately low, length somewhat less than width across palpebral lobes. Glabella very low, anterior half flush with fixigenae, posterior half rises slightly above. Axial furrow narrow and shallow, converging forward at sides of glabella, curvature medium across front. Four very shallow sets of glabellar furrows visible only on internal moulds, anterior two closely spaced and inclined slightly forward, third set transverse, posterior set transverse and then forked with one branch inclined forward and other back. Palpebral lobes narrow and downsloping, centred slightly posterior to glabellar midpoint, nearly half as long as glabella. Preglabellar field longer (sag.) than border, side view shows forward slope continuous with that of glabella. Anterior border furrow shallow; border flat, slopes forward less steeply than preglabellar field. Facial suture slightly divergent from palpebral lobes to anterior border furrow. Posterior area not as wide (tr.) as occipital ring. Occipital furrow narrow and shallow near ends, very shallow and wider near middle. Occipital ring short (sag.) and bearing a node.

Pygidium tentatively assigned to this species has shape of half dome, curvature across top broad, becoming steep near margin. Axis low in front, flush with pleural region in back, consisting of six rings and a terminal piece; anterior two rings each exhibit two faint, transverse ridges. Pleural region marked by six pleural furrows of medium depth and five narrow and shallow interpleural furrows. Surface of cranidium and tentatively assigned pygidium nearly smooth.

Remarks. A single pygidium that may be congeneric with these has been described by Resser (1939a) as *Tonkinella idahoensis*. It differs from the present pygidia in having shallower furrows on the pleural region and a lower axis.

Occurrence. *Glossopleura* (?) Faunizone, upper member, locality 18.

Achlysopsis hemitora gen. et sp. nov.

Plate 42, figs. 12–16

Material. Thirty cranidia 1·8–10·0 mm. long.

Description. Cranidium low, length slightly less than width across palpebral lobes. Glabella moderately low, sides straight, curvature broad to medium across front. Four sets of shallow glabellar furrows visible on internal mould; anterior two weak and inclined forward; third normal and then forks into two branches, one inclined forward and the second back; posterior set forks into two branches, one directed slightly back and the other strongly back. Axial furrow shallow. Palpebral area nearly flat, slightly downsloping. Eye ridges well developed on internal mould and swept strongly back. Palpebral lobes slightly downsloping, half as long as glabella, terminating just ahead of occipital furrow. Preglabellar field slopes moderately forward, slightly longer (sag.) than

border. Facial suture directed straight forward from palpebral lobe to border furrow, slightly divergent on flattened cranidia, slightly convergent on those that are transversely compressed. Anterior border furrow shallow and uniform except near middle where it shallows because of very small swelling which extends a short distance on to border. Posterior area nearly as wide (tr.) as occipital ring, distal ends rounded. Occipital furrow narrow and deep near ends, shallow and bowed forward near middle. Occipital ring short (sag.) and bearing a node. Test covered with small granules, preglabellar field and adjacent fixigena marked by longitudinal venation.

Remarks. Cranidia of this species differ from those of *Achlysopsis liokata* sp. nov. by having a higher glabella, wider palpebral area, and more posteriorly located palpebral lobes.

Occurrence. *Albertella* Faunizone, upper member, locality 15.

Genus ANTAGMUS Resser 1936

Type species. *Antagmus typicalis* Resser 1937 [= *Ptychoparia teucer* (Billings) Walcott 1886; non *Conocephalites teucer* Billings 1861].

Antagmus arenosus sp. nov.

Plate 36, figs. 6-10

Material. Six cranidia 6.7-8.3 mm. long.

Description. Cranidium broadly convex in both directions. Glabella low, sides straight to very slightly concave and converging forward, front broadly curved. Posterior two sets of glabellar furrows visible on outer surface of test; four sets visible on internal mould, anterior two sets short and faint, third set has transverse and posteriorly inclined branch, posterior set has two branches inclined back. Facial suture divergent between palpebral lobes and anterior border furrow. Palpebral area broadly curved (tr.), average slope is outward; front of anterior area slopes steeply toward anterior furrow; medial portion of preglabellar field nearly horizontal. Anterior border furrow wide and deep distally, shallow near axial midline. Anterior border upwarped in front view; in plan view rear margin evenly curved on upper surface of test, but exhibiting slight medial recurvature on internal moulds. Eye ridges of medium strength; palpebral lobes located slightly posterior to glabellar midpoint, length approximately one-third that of glabella. Width (tr.) of posterior area approximately equal to that of occipital ring. Posterior and occipital furrows narrow; occipital ring narrow (exsag.), only slightly broader medially (sag.), and bearing a node. Both upper and lower surfaces of cranidium are covered by medium-sized, closely spaced granules.

Remarks. A very wide palpebral area serves to distinguish this species from others in the genus *Antagmus*.

Occurrence. Upper *Olenellus* Faunizone, lower member, locality 1085.

Genus *CABORCELLA* Lochman 1948

Type species. *Caborcella arrojensis* Lochman 1948.

Caborcella granosa (Resser)

Plate 39, figs. 9–15

1939a *Poulsenia granosa* Resser, p. 59, pl. 13, figs. 19, 22–30 (non figs. 20, 21).

? 1939a *Poulsenia bearensis* Resser, p. 60, pl. 13, figs. 5–8.

1944 *Poulsenia granosa* Resser; Shimer and Shrock, p. 615, pl. 259, figs. 6, 7.

1951 *Caborcella granosa* (Resser); Rasetti, p. 211.

Material. Fifty-two cranidia 1.7–12.6 mm. long and two pygidia 2.3 and 3.1 mm. long.

Description. Cranidium considerably wider across palpebral lobes than long, convex, and deeply furrowed. Glabella cone-shaped, sides slightly concave, front medium to strongly curved. Four sets of glabellar furrows, anterior two sets inclined forward, posterior two inclined back, posterior set somewhat arcuate. Palpebral area convex; eye ridges strong. Palpebral lobes centred well posterior to glabellar midpoint, tilted inward, and approximately one-third as long as glabella. Preglabellar field narrow (sag.); adjacent anterior area of fixigenae slopes steeply forward. Border rounded in side view, broadly uparched in front view with locally stronger arch near middle. Facial suture directed nearly straight forward for first half of distance from palpebral lobe to border furrow, then curved slightly inward. Posterior limb considerably wider (tr.) than occipital ring. Occipital ring short (sag.); occipital node, if present, is very small.

Pygidium short, width more than twice length, antero-lateral margins broadly curved, postero-lateral margins straight and rapidly converging toward broad curvature behind axis. Axis wide and low, articulating half ring very short (sag.), one well-defined axial ring, remaining rings fused to a terminal piece which reaches posterior edge of pygidium. Pleural region marked by one pleural and one interpleural furrow, sloped steeply downward along postero-lateral margin of pygidium. Test ornamented with large tubercles and small granules, tubercles are best developed near edges of furrows.

Remarks. Resser (1939a) correctly assigned one pygidium (pl. 13, fig. 19) to this species, but also assigned to it pygidia (pl. 13, figs. 20, 21) belonging to *Amecephalus laticaudum* (Resser) 1939b. In addition, two incomplete cranidia described as *Poulsenia bearensis* Resser 1939a may belong to this species. These cranidia cannot at present be placed under *C. granosa* with certainty as they have a slightly longer preglabellar field and obvious venation on the forward portion of the anterior area. These features may be within the limits of interspecific variation and would be considered to be so if more parts of *C. bearensis* are located and found to match like parts of *C. granosa*.

Occurrence. *Albertella* Faunizone, upper member, localities 8, 9, 71, 11, 12, and 15.

Caborcella clinolimbata sp. nov.

Plate 41, figs. 33–35

Material. Four cranidia 3.1–4.1 mm. long.

Description. Cranidium convex, length less than width across palpebral lobes, furrows shallow to moderately impressed. Glabella is of medium height, sides straight and slightly